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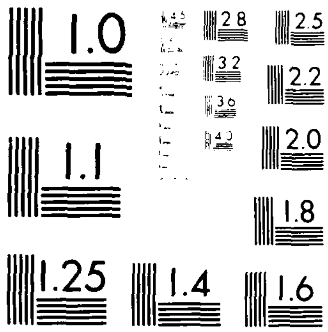

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C^3EVAL MODEL DEVELOPMENT -- 1986

Volume I: Overview

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Robert F. Robinson

Joseph W. Stahl

M. L. Roberson (Applications Research Corporation)

~~April~~ May 1987

Prepared for

Joint Chiefs Of Staff

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This is an interim report on the 1986 work on the extension and development of the C3EVAL model. The model is to permit assessment of the effects on combat of changes in command and control processes and communications network structure and capacity. The model has had a partial pre-processor added to assist possible analyst/model users to input data and a post-processor to provide graphic display of some outputs. The command structure includes the Central European command nodes from division to SHAPE for US forces. The nodes have had input and output limits added to permit representation of degraded operation as under attack or when the unit is moving. The corps level force allocation procedure has been improved. Some processes have been randomized. The corps operates on information different from that available at the division or combat unit, due to time delays, randomness, scenario inputs and corps controls allocation of corps support resources. The impact of changes in the C3 system can be seen in changes in weapon losses, non-arrival of close air support and messages delayed/lost as well as other operations-related elements.

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C^3EVAL MODEL DEVELOPMENT -- 1986

Volume I: Overview

Robert F. Robinson
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May
~~April~~ 1987

INSTITUTE FOR DEFENSE ANALYSES

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PREFACE

This paper is a report on the continuing development of the C3EVAL model undertaken by the Institute for Defense Analyses in response to Task Order T-I6-309, Theater/Tactical Command, Control and Decision Process Analysis Methodologies subtask, Development and Test of C3EVAL Model, under Contract No. MDA 903 84C 0031. The work is for the Office of the Joint Chiefs of Staff/Command, Control and Communications (J-6). The purpose of the IDA program is to provide JCS/C3S with a means for the evaluation of theater/tactical command, control and communications in terms of military operations. The previous work was reported in IDA Paper P-1882, C3EVAL Model Development and Test, October 1985, UNCLASSIFIED.

This report is in two volumes. Volume I is the description of the model and its capabilities. Volume II is the programmers' manual.

The reviewers on this project were:

Mr. James L. Freeh
Dr. Donald L. Ockerman
Dr. Eugene Simaitis

Their assistance and suggestions were of great value.

A-1

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GLOSSARY

AAFCE	Allied Air Forces Central Europe
ACR	Armored Cavalry Regiment
AD	Armored Division
AFCENT	Allied Forces Central Europe
ASOC	Air Support Operations Center
ATAF	Allied Tactical Air Force
4ATAF	4th Allied Tactical Air Force
ATOC	Allied Tactical Operations Center
BAI	Battlefield air interdiction
CAS	Close air support
CENTAG	Central European Army Group
CRC	Control and Reporting Center
C2	Command and control
C3	Command, control and communications
EAC	Echelon above corps
ECM	Electronic countermeasure
EW	Electronic warfare
F/R	Force ratio
JCS	Joint Chiefs of Staff
MD	Mechanized Division
MRD	Motorized Rifle Division
MRR	Motorized Rifle Regiment
NATO	North Atlantic Treaty Organization
OMG	Operational Maneuver Group
PTT	Postal Telephone and Telegraph
RDN	Random distribution number
SHAPE	Supreme Headquarters Allied Powers Europe

TACP	Tactical air control party
TAFIG	Tactical Air Force Interoperability Group
TD	Tank Division
TFCA	Total force capability assessment
TO&E	Table of organization and equipment
TR	Tank Regiment
TRITAC	Tri-Service Tactical Communications Service
TTY	Teletypewriter
USAFE	US Air Force Europe
USAREUR	US Army Europe
USEUCOM	US European Command
WOC	Wing Operations Center

EXECUTIVE SUMMARY

A. OBJECTIVE

The purpose of the development of the C3EVAL model is to provide a means for the evaluation of theater or operational level command, control and communications (C3) in terms of combat consequences.

B. BACKGROUND

The program for the development of the model has been designed to lead through an evolutionary development to provide a flexible tool that can be used as a work station by the staff of the Joint Chiefs of Staff (JCS) to assess the relative merits of C3 system's alternatives in different scenarios. Changes in the C3 system include changes in architecture, connectivity and capability due to changes in subsystems. Differences in scenario are intended to include changes in situation, combat forces and force mixes. The model is an aggregated model that represents aggregated communications paths and nodes or command units.

The model is designed to assess the flow and use of information. Information flow is represented by the delivery of explicitly identifiable messages, e.g., intelligence reports, operations reports, spot reports of various kinds, requests and orders. The command and control process is represented by an expert system using rules for new message generation and by "decisions" based on information available (or perceptions). The combat process on the ground is represented by an attrition calculation using the matrix method. The Lanchester-based matrix method allows operations on the coefficients and quantities of weapons available as a result of changes in the relative status of the opposing forces or in response to orders received by the combat unit. Changes in the status of the forces are reported through the standard reporting procedures as are requests for additional support.

The user of the model can introduce changes in the capability of paths or nodes to represent effects of electronic warfare, units on the move or combat damage to the paths or nodes. The user can also cause changes in the combat status of the units by the introduction of external scenario-generated messages. Changes in connectivity or procedure can be introduced as well as system changes. By these changes the user can make comparative assessments of C3 and its capability under various conditions. Message flow, responsiveness of the C3 system and the interaction of combat operations on C3 and C3 on combat operations can be investigated.

These model characteristics provide the means for a variety of possible applications of the model. Some examples are:

1. The model is to provide the JCS/Command and Control (J-6) with a means for the assessment of C3 effectiveness.

2. If new C3 systems are introduced, they can be evaluated in terms of the impact on operations.

3. As with systems changes, procedural changes such as the message requirements for the generation of new messages can be explored. The effects of changes in message preparation time can be adjusted, representing either procedural or system changes.

4. The impact of the major effects of counter-C3 operations on either friendly or enemy forces can be investigated. The counter-C3 effects can be represented by changes in communications capacity and in the capability of the command node to accomplish its tasks during specified time intervals.

5. The needs for additional communications paths, secure paths or dedicated paths can be investigated.

6. The effects of lost and delayed messages and thus the need for higher capacities of paths or changes in procedure could be assessed.

C. OVERVIEW

The model has been under development for about three years. To provide a basis for test, the model is currently configured to correspond to the command and control of the Central European Army Group (CENTAG) of NATO, with emphasis on U.S. forces. The model is designed to permit the user to represent any command structure (i.e., arrangement of command nodes and communications paths with interaction with operations). As shown in Figure ES-1, the nodes chosen for the current activities extend from SHAPE to the

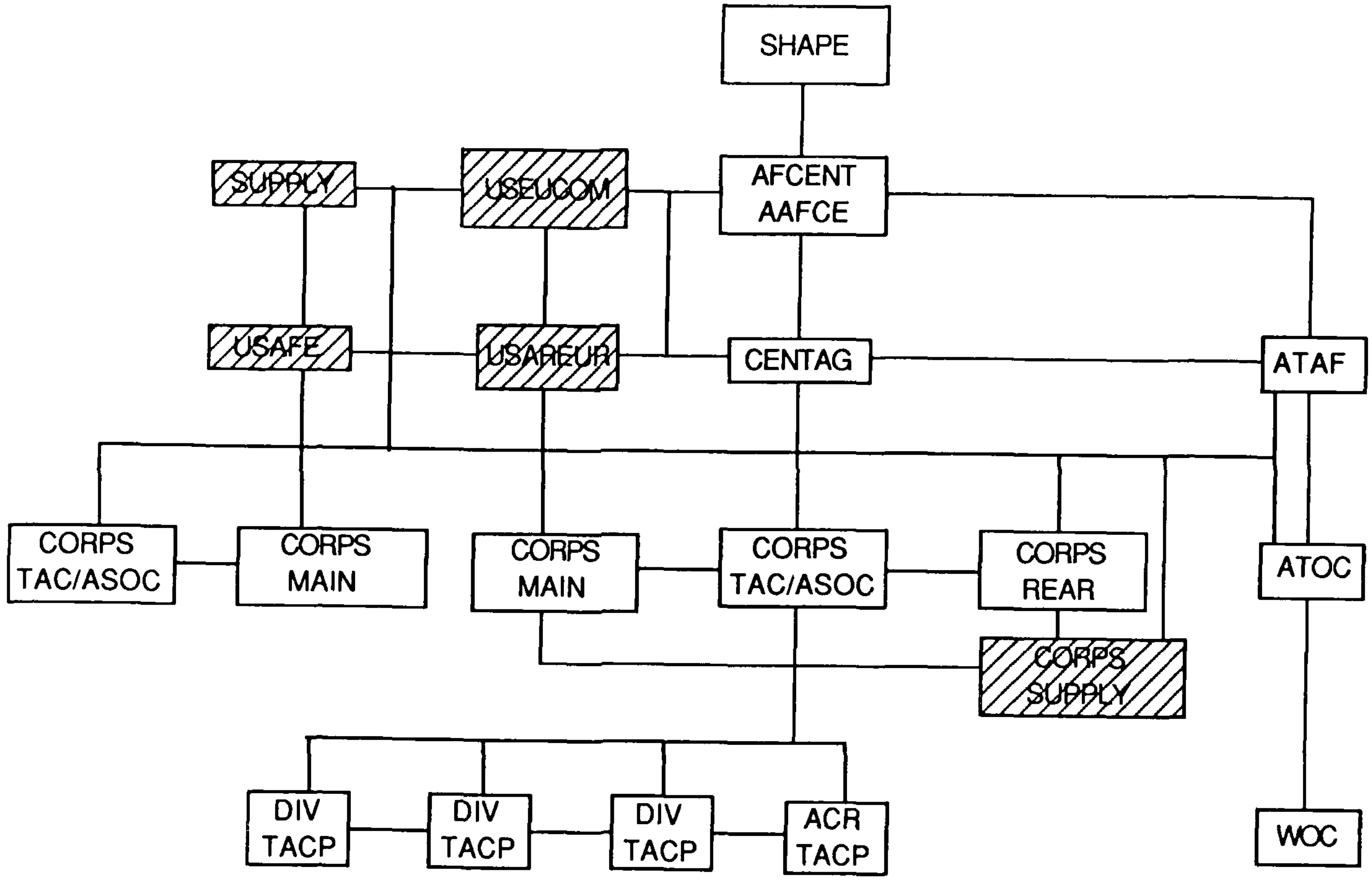


Figure ES-1. COMMAND AND CONTROL CONNECTIVITY IN MODEL divisions of the U.S. V Corps. The shaded nodes are those added during the FY86 effort. The effort included the addition of appropriate communications paths and the introduction of new rules for the messages that are required by the C3 components that have been added. These include logistics messages and the reports and orders that proceed through the added nodes.

When the node and path structure is complete and the rules and messages appropriate to the command interconnectivity and scenario have been installed, the model is ready for use. The usual approach will be to run a base case with all nodes and paths operating at their specified capability. The scenario will specify when units move into or out of combat, provides for reinforcements, specifies the pre-planned sorties and determines the basic intelligence inputs. The scenario inputs will provide the external message inputs that are necessary for the situation under consideration. The intelligence input on which the Corps Tac Headquarters is making "decisions" may not be an accurate representation of the opposing forces. The calculation of force ratio for each of the divisions under the command of the Corps Tac is based on the intelligence estimate of the force facing each division and the reported status of the friendly forces. For Blue forces the allocations of artillery, helicopters and close air support (CAS)/battlefield air interdiction (BAI) are made on the basis of user-specified values of the force ratio.

Once a run is started, the generation and distribution of messages proceeds as a result of the rule-based expert system. For example, certain messages and reports will be generated as the result of the passage of time, i.e., a report may be required every 12 hours. Certain other messages will be created as the result of the receipt of reports, e.g., a specified set of spot intelligence reports from divisions may cause the Corps Tac to make an intelligence report to CENTAG. The occurrence of certain specified force ratios at division level will cause the division to request corps support. Corps will respond with a promise of support or a refusal. There are at present over 400 rules in the test model. Of these, about 30 were added during the current year effort to include logistic messages, and the rules for approximately 80 other messages were altered to account for the additional command nodes and the appropriate reporting procedures.

The message pattern can be altered by the introduction of random processes (at the choice of the user). The user must provide a distribution for each process. The processes available include:

1. Probability that CAS will arrive at the target.
2. Probability of a partial message. If the originator is identifiable, the receiver requests that the message be sent again, otherwise the message is lost.
3. Probability of a lost message.
4. Message length randomly increased or decreased.
5. Message delayed in the create process.
6. CAS request delayed randomly.
7. Random modification of message content (e.g., report of operational status numbers or intelligence report numbers).

As can be seen, the perceptions of the situation at Corps Tac where allocation decisions are made differ from the "real world" not only by the standard transmission time delay, but also by the arrival of incomplete or false information. Messages can also be delayed randomly.

In order to establish the connection between the command and control operations and combat operations, there is a representation of the ground force attrition processes. To calculate attrition, a matrix method is used that allows for the fires of N Blue weapons on M Red weapons. As the allocations of fires, engagement rates and probabilities of kill are in the matrix coefficients, they can be operated on to cause a representation of changes in posture or other response to the situations in which the engaged forces find themselves. The numbers of weapons on each side also change as a consequence of attrition or by the arrival or withdrawal of forces by the scenario or as the result of requests for corps support for artillery, helicopters or CAS/BAI.

The airbase model contains a representation of a Wing Operations Center (WOC) and a Control and Reporting Center (CRC). The WOC controls the allocation of available aircraft on the ground at the aggregated airbase to requests for air support. The CRC controls the sorties once they are airborne. The CRC process calculates the time over target, modifies the appropriate unit combat matrix to include the sorties, calculates en route attrition and schedules them for control by the WOC after they land after accounting for attrition in the combat area.

The model is supported by a menu-drive data base manager and a graphics package that can be used to display results. Representative of the results that can be displayed are time histories of the messages that have been received and delivered at specific command nodes (Figure ES-2) and time histories of the attrition of Blue and Red forces (Figure ES-3) Summary displays (bar charts) and tabulations are also available. The user can also request a Corps Status Report when desired.

The model is written in FORTRAN 77 and it is fully documented and commented. Dimensionless code is used. The pre- and post-processors are dependent on software that supports the VAX 785 system.

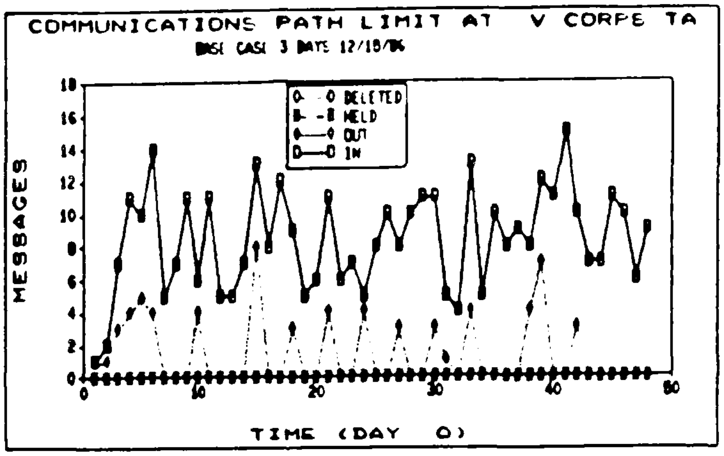


Figure ES-2. MESSAGES FOR CORPS TAC, DAY 0

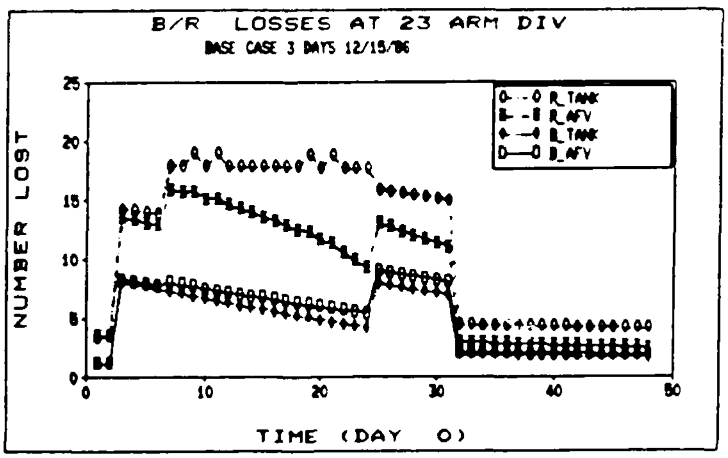


Figure ES-3. BLUE/RED COMBAT LOSSES 23RD ARMORED DIVISION, DAY 0

I. INTRODUCTION

A. OBJECTIVES

The purpose of the development of the C3EVAL model is to provide a means for the evaluation of theater command, control and communications (C3) in terms of combat consequences. The model is for use by the Joint Chiefs of Staff (JCS)/J-6 staff to assess theater C3 at a level appropriate to Joint Staff needs. It is essential that only a minimum of support for the model be required. The data must be available from tests, history or command post exercises and installed so that it is readily accessible to the model and to the user. A quick turnaround capability must be available for cases examined. The model is to be run on a VAX computer.

B. BACKGROUND

The development of the C3EVAL model has evolved from a need expressed by JCS/J-6 for a means to assess C3 in terms of the impact on military operations and on combat effectiveness. A survey of existing models revealed that the requirements for the ability to assess the effects of C3 at higher levels of command within a theater, for ease of use and quick turnaround and a directly identifiable relationship to military operations could not be met.

The model has been under development for about three years. In order to provide a basis for test, the model is currently configured to correspond to the command and control of the Central European Army Group (CENTAG) of NATO. The lowest levels of command represented are divisions and the Armored Cavalry Regiment (ACR). The corps in the model for test purposes is the US Army V Corps. (A representation of VII Corps exists in skeleton form.) as the effort progressed there have been added command nodes, communications paths, processes and functions, representation of realistic effects (e.g., random processes and limits on system operational capability) and improvement of the input and output processors to facilitate use. During the development process, all components of the model have been thoroughly tested as they were added. The data in the data base is unclassified.

It is emphasized that the model is an aggregated model of C3. It represents the communications paths as aggregates of all communications links of a type between two nodes or command units. The "types" may be voice, data or they may be indicated to be an Air Net, Logistic Net, Operations Net or other, at the user's choice. The communications processes are represented by the delivery of explicitly identifiable messages, e.g., intelligence reports, operations reports, spot reports of various kinds and requests. The command and control processes are represented by new message generation and by "decisions" based on information available at the command node to request or approve the request for additional combat support resources. Military operations are represented by a matrix calculation of attrition.

C. APPROACH

The approach taken in the development of the model has been to start with a fairly simple network of command nodes, communications paths and matrix attrition calculations. These processes and functions are tested and then additional functions and processes are added and tested.

The model is time-stepped. This choice was made in order to provide greater flexibility to the user. Currently the time increments are one-half hour. The time increment is the user's choice, however, data used must correspond to the selected time increment. The flow and use of information in the form of explicit messages from command node to command node along communications paths, all selected by the user, represents the operation of the command and control system. Combat operations are represented by a matrix calculation of attrition currently with 13 weapon types. The message generation/ decision process at the command nodes is rule-based. The rules are input by the user.

The model is written in FORTRAN 77, and it is fully documented and commented. Dimensionless code is used. Pre- and post-processors are installed. However, these processors are dependent on software that supports the VAX 785 system.

II. C3EVAL MODEL, CONCEPT AND DESCRIPTION

A. INTRODUCTION

This chapter provides an overview of the concept on which the C3EVAL model is based and a description of the current capabilities of the model. The overview of the concept provides the design intentions, the capabilities of the model and some discussion of possible uses. The model consists of three major elements: data manager, combat simulation and display manager. The data manager is an interactive pre-processor that creates and modifies the data dictionary and generates the input files for the simulation. The simulation is controlled by the scenario data in its input files. Graphic representations of the results of the simulation are provided by the interactive display manager. The description of current capabilities is illustrated by examples of the application of the model derived from tests that have been run.

B. CONCEPT

The concept of the command, control and communications (C3) evaluation method developed rests on the idea that the leading principle of command and control and its relation to operations is the evaluation of the flow and use of information and its potential impact on combat. The flow of information occurs through the movement of messages. Information and messages are used to cause or report actions. In a command and control system, intelligence processes are invoked to collect information on the nature and activities of the enemy forces. Reporting processes result in information on the status, activities and plans of the elements of the forces. The information so collected is processed (used) to generate plans, directives and reports of actions taken and status of units. Further messages are generated and these flow through the C3 system to action nodes where military operations occur. Messages in this context are all discrete packets of information in which information is organized for use and movement through the system. Messages have priority, preferred modes of communication, preferred routes for delivery and length (in characters).

The C3 system is described as a hierarchy of nodes and paths. The nodes are the command posts and messages are sent between nodes along paths. In all nodes there are processes that represent the command and control functions. Nodes that are the command posts of the combat units, supply depots, air bases or others as designated are assigned the appropriate function to represent the military operations for which they are assigned responsibilities. The rule-based message generation processes represent the command and control functions. A direct interface with combat and support operations is provided so that if messages concerning additional support, changes in status or arrival of additional forces on either side occurs, then delays, non-arrival of messages or other disruptions occur, the impact on combat operations can be measured and the changes in the C3 system related to those changes.

The primary assumptions are:

1) The basic measurable element in C3 system operation is the message.

2) The use of information can be represented by:

   • A decision rule process that simulates the transformation of messages of one type to another and the aggregation of combat information at a command node.

   • Changes in posture of the combat forces and allocations of forces and supplies.

3) The transformation processes or decision processes can be represented by an idealized process that operates according to a system of decision rules.

Rule systems are designed for types of node, e.g., division command post, corps tactical operations center or other. The rule systems cause messages to be generated and "decisions" made as to allocation of resources. The rules constitute an expert system.

The model concept allows for changes in the status of the combat and combat support forces, changes in communications capacity and changes in the capability of the command post nodes through instructions introduced through a scenario data set. The concept of the model also includes the capability to introduce stochastic events to account for the properties of the communications system and the command and control decision process.

C. POSSIBLE APPLICATIONS (*)

To illustrate the characteristics and capabilities of the model, some examples of possible applications will be briefly considered. These examples are hypothetical since the model so far has been run only in an extensive test program to assure the elimination of "bugs" and to provide cases showing the specific capabilities. Some of the possible applications would require some modification of the model and/or the use of other analyses or models to provide input data.

1. C3 Effectiveness

The primary objective of the model is to provide the Joint Chiefs of Staff/ Command, Control and Communications Systems (JCS/J-6) with a means for the assessment of C3 effectiveness. The primary case was chosen to be Central European operations. It is assumed that assessment of the effectiveness of C3 means a measurement of whether the system will provide the means for directing and controlling the forces within the purvue of the C3 system being considered. The rule system installed will represent current doctrine. The assessment thus involves the measurement of the effect of both rapid and gradual degradation of the availability of communications paths and of command nodes over a period of several days using a scenario for the beginning of a conflict in Central Europe. An important additional test case for assessment could be the investigation of the capability of the C3 system to respond to the demands that would be imposed by an incursion of a Soviet Operational Maneuver Group (OMG) into one corps area. The scenario for the OMG incursion would form the basis for an assessment of the ability of the system to respond and to deliver the commands on a timely basis in order to counter the "breakthrough."

2. System Changes

If new systems are introduced that are expected to improve capability, they can be evaluated in terms of the C3 impact on operations. For example, if means for greater communications capacity are proposed, the capacity of the appropriate communications paths can be easily increased in the model to assess the effects of this change. If means are

*The asterisk denotes new material added since the previous report.

introduced by which messages can be more rapidly prepared, this too could be measured by changing the preparation time for the affected messages.

3. Procedure Changes

As with system changes, the message requirements for the preparation of new messages can be readily changed and the effects of changes in preparation time can be adjusted. Procedures for hand over of command functions can be done. Alternative doctrine or organizational structures could be tested.

4. Impact of Counter-C3

The impact of the major effects of counter-C3 operations on either friendly or enemy forces can be assessed in terms of the impact of changes in communication capacity during specified time intervals or changes in the capability of the command node during specified time intervals. The change in communications capacity would represent the effect of jamming over scenario-specified time intervals. Limitations on the ability of the command nodes to accept or produce messages can represent the reduction in capability of the command node due to attack on the indicated nodes.

5. C3 System Requirements

The needs for additional communications paths, secure paths or dedicated paths can be investigated. The impact of a greater capability for units on the move or otherwise limited can be assessed through the use of the node limiters. The effect of systems that would appreciably reduce processing time could be investigated through reductions in processing time. The "random" capability will permit investigation of the effects of different distributions on the decision processes.

6 Effects of Lost and Delayed Messages

Using the random processes available, a standard reference case could be produced and then, with the introduction of selected random distributions, the effect of lost and delayed messages on the capabilities of the C3 system could be tested to determine if additional paths, higher capacities of paths or changes in procedure would mitigate the effects of the losses or delays.

D. GENERAL DESCRIPTION

The major elements of the C3EVAL model are as follows:

1) Node and path structure: There are input rules for the operation of the nodes.

2) Action models: The models of combat that interact with the C3 hierarchy.

3) Data structures: The data for node and path designations, TIMET inputs, combat data and decision rules.

4) Pre-processor: A means to provide for user friendly input and validation of data.

5) Post-processor: A means for developing graphics presentations of the results of a model run.

The node and communications path structure are chosen by the user so that any desired arrangement of the nodes and paths can be represented. The level of aggregation is also user chosen. This is reflected in the characteristics of the combat units, in the time interval chosen and, naturally, in the number of nodes. Changes in time interval affect the decision rules and the combat data used. In the current version, divisions and armored cavalry regiments are the smallest ground combat units and flights of aircraft are the smallest air unit.

E. DATA INPUT

The data input structure contains all the data necessary for the operation of the model. Very little data are contained in the model, so the user can readily control the cases to be run. The full schedule of data inputs is as follows:

1) Nodes: The designation of the nodes, their commander (to whom do they report), their subordinates (who reports to the node), coordinating nodes, and alternative nodes for sending messages when normal lines of communications are unavailable.

2) Node Limits: Input and output limits to represent constraints on the capabilities of the nodes to either receive or process messages. Node limits can be specified by time interval.

3) Communications Networks: The specifications of the number of paths, their kinds and their capacities that connect each node with other nodes. Communications capacities can be specified by time interval.

4) External Messages: All scenario inputs that include messages that report, for example, electronic warfare (EW) events, changes in the number of weapons available to combat units or changes in posture of combat units.

5) Combat Data: The numbers of weapons assigned to each combat unit and their posture.

6) Artillery Data: Corps support artillery, characteristics and numbers.

7) Aircraft Data: Types of aircraft, numbers of aircraft and availability by time period.

8) Helicopter Data: Characteristics and numbers by time period.

9) Rules: Representation of the decision processes by which messages are generated. Rules are specific to the node type, organization and doctrine of the C3 system being considered.

F. SIMULATION DESCRIPTION

The model is designed to be able to represent any command structure that is an arrangement of command nodes and communications paths with an interaction with operations and, in particular, with combat operations. The working model as it is currently structured represents a slice of the command structure in Central Europe, as shown in Figure II-1. This smallest ground unit is the division and is the combat unit. The levels of command extend above corps to Central European Army Group (CENTAG), Allied Forces Central Europe (AFCENT)/Allied Air Forces Central Europe (AAFCE) and Supreme Headquarters, Allied Powers Europe (SHAPE). The representation of corps is such that there are nodes for Corps Main, Corps Tac and Corps Rear. The tactical air control parties (TACP) at division and the Air Support Operations Center (ASOC) at Corp Tac have been

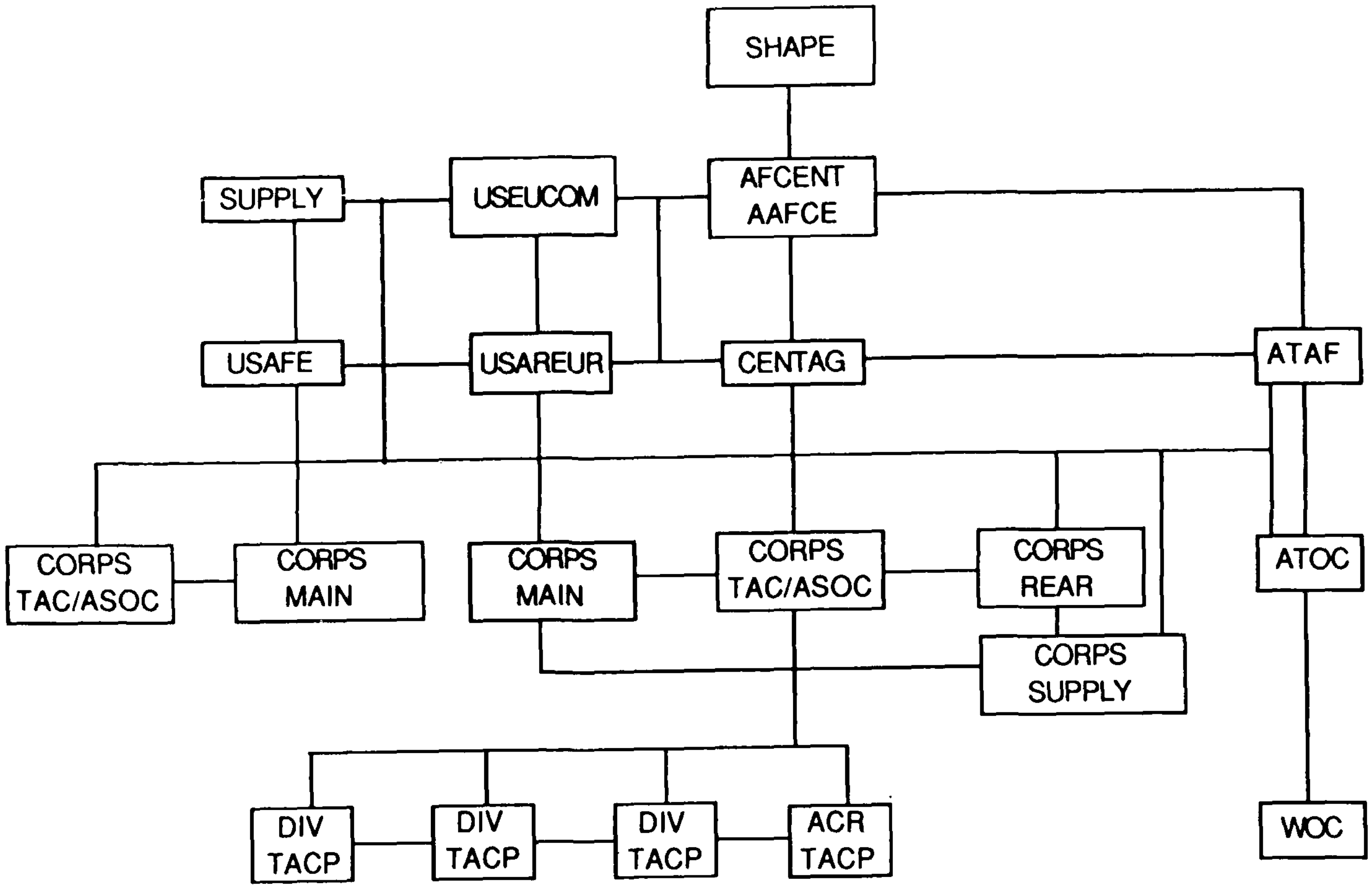


Figure II-1. COMMAND AND CONTROL CONNECTIVITY IN MODEL combined into the nodes for division and Corps Tac. This means that there is no message delay between the Air Force and Army units. The message-generating capability of these units for sending messages to appropriate Air Force or Army units is not altered and each can still perform its appropriate functions. There is a corps supply node (*), a supply node for US national logistics (*). The Air Force nodes include the Wing Operations Center (WOC), Allied Tactical Operations Center (ATOC), 4th Allied Tactical Air Force (4ATAF) node and the US Air Forces Europe (USAFE) (*). The higher US Army commands include US Army Europe (USAREUR) and US European Command (USEUCOM) (*). Rules and messages have been introduced for all existing nodes. The user can pick any arrangement of nodes and paths that may be desired. This is a part of the flexibility of the model. While the chosen command structure is for Central Europe, the command structure may be chosen so that it can represent that of a service or joint or combined force, provided that the rule structure and messages can be specified. The user may establish as many nodes as desired. As nodes and paths are added, the turn-around time will increase. It is probably worth noting that in the use of the model the point may be reached when particular problems are to be investigated, that only that portion of the structure relevant to the particular problem should be retained. An example might be a representation of Army and Air Force air defense operations. This would mean that turn-around time for that investigation would remain low. Care must be taken in such simplifications of structure to avoid serious alterations in the behavior of the system and the flow of messages. A straightforward example of the effect such a change would be the absence of some of the alternative paths for message delivery.

The user establishes the number and description of the paths that connect the nodes. While it is emphasized that there is aggregation of the communication paths, there is considerable flexibility in their designation and use. Figure II-2 shows the current path connections for V Corps Tac. There are 32 distinct paths that are identified as secure voice, open voice, digital and courier. The capacity of the path is defined by the number of characters that can be transmitted within the designated time interval (in this case, within one-half hour). This means that when voice mode is being used, the capacity of the path will be limited to the number of characters that can be spoken within the one-half hour and not by the capability of the system to transmit millions of bits per second. The paths can be designated for specific use, although this has not been done in the current work. An

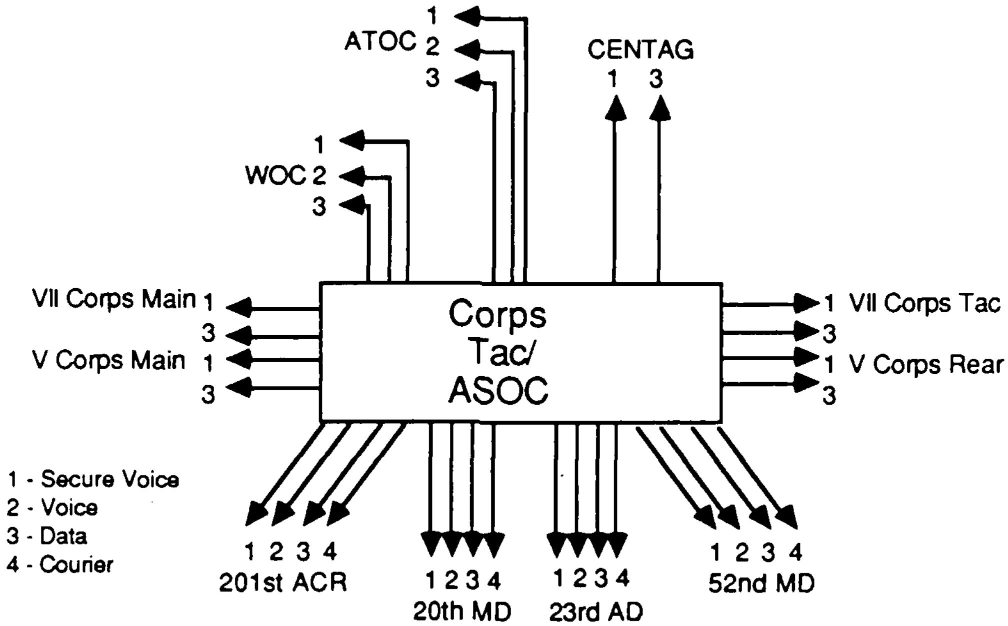


Figure II-2. PATH CONNECTIONS WITH V CORPS TAC

example of such a designation would be the identification of paths five, six and seven as part of the Air Force Tactical Air Net. The Air Force messages that would use this net would have to be so designated in the description of the message. The form for message specification is included in Chapter III, Section C.

The paths represent the total capacity available ·˜ the specified mode of transmission between two nodes. They do not specifically represent a particular communications link except in the fact that they include that link with all other links of the specified available kind between the two nodes. If there are switches between the two nodes, they are not separately identifiable. If the communications capacity is diminished in a given series of time intervals by jamming, unreliability of a switch or combat damage to a switch, this is represented by a reduction in capacity by an amount input by the user. The nature of changes in the communications system due to changes in message switches can be determined from a communications network model to provide data for input to the C3EVAL model. There is available a random distribution indicator for probability that a message is lost for each path as a function of time (*).

Each node has the same internal structure (see Figure II-3). Each node can be designated as belonging to a generic unit type, i.e., division or WOC, and when rules are developed for that generic type all nodes designated to be of that type will operate according to those rules. Each command unit has three files on the input side that may

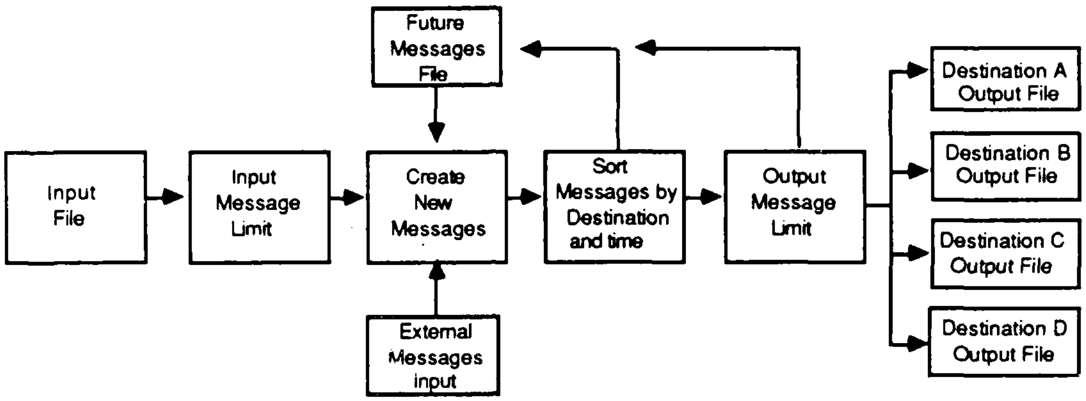


Figure II-3. NODE INTERNAL STRUCTURE

contain messages. The messages in these three input files are reviewed in each time interval. The three input files are (1) the file of messages from other command nodes/units, (2) the file of messages input by the user (the external file) that are scenario-specified messages and (3) the file of messages held from a previous time interval for one of three reasons. The first reason is to represent the fact that it may take more than one time interval to process a specific kind of message, e.g., the process time for certain types of reports may normally take two hours to produce. In this case the messages will be held in the future file for four time intervals. The second is that scenario-specified messages may be held in the future message file if the capacity of the available communications paths is exceeded before that particular message could be sent. In that case the message will be held in the future message file and an attempt will be made to send it during the next time interval. If it still cannot be sent, the process will be repeated until the designated age of the message has been exceeded and the message will be destroyed/killed. The output record will indicate how many and which messages have been destroyed/killed and how many have been held. Finally, messages may also be held in the future message file when they have not been sent, due to the output message limiter. Specific messages may be held for a period of time determined by a random draw if "random" has been turned on and the message is one of those that have been designated.

The first process to which messages are subjected may be the input message limit. This limitation may be set by the user for specified numbers of time periods by node. It is intended to represent such events as a limitation on the ability to receive messages due to events such as damage to antennas or the unit's being on the move. The limitation is designed to pass priority one messages and a specified number of lower priority messages. The input file messages are sorted as they come in.

The "create new messages" process is central to the operation of the model of the command node. New messages may be generated because it is time for that message to occur, i.e., it is a periodic message. A new message may be created because a certain message has arrived. The new message in either case may require the existence of one or several specified messages in the file before the new message is created. The new message will be created according to the rules that have been established in the rule data file. Rules are discussed under the rule data development. Node limits are also included for random distribution indicators for message length modification (*), message delay (*) and close air support (CAS) request delay (*). All of these are available as a function of the desired times.

New messages are then sent to "Sort Messages by Destination and Time." If the time required to create the message is greater than the specified time interval (as specified in the message characteristics, Chapter III, Section C), then the message is sent to the Future Message File until the appropriate time arrives. If the message is to be sent within the current time interval it is sent on according to priority. This can be used, for example, to represent limitations on the capability of the node to accomplish its functions. Those messages that are not sent to the destination files are sent to the Future Message File. An attempt is made to send the message in the next time interval. This process will continue until the specified age of the message is reached, at which time the message is killed. If the message is sent to the appropriate destination file, an attempt is made to send the message via the specified communications mode by the specified route. The user may specify up to two alternate modes and routes to be used if the preferred mode or route is not available. If no mode or route is available, the message is returned to the Future Message File and an attempt will be made to send it in the following time interval until the age of the message is exceeded.

In the version of the model under development, the functions of the corps are central to the operation of the command and control system. Included in the rule/decision processes for Corp Tac are rules for the allocation of corps support combat resources. These processes include the use of an estimate of the combat situation as perceived at Corps Tac based on the Corps Tac postulated strength of friendly and enemy forces. Specifically, the division will send a message to corps whenever new enemy forces appear before it. The message may report the actual unit or it may mis-report, e.g., if the unit is the 10th Mechanized Rifle Division, it might be reported as an armored division depending on the scenario input or the external message specified by the user. This means that when the message arrives at Corps Tac, headquarters will check its list of table of organization and equipment (TO&E) that have been specified by the user for that type of unit and will use the values from that table to calculate force ratio. If a correction or change message is sent from division to corps according to the user input (external message), then corps will change in its future calculations to the corrected information. The messages will, of course, be delayed by at least the transmission times. There may be additional delays due to random factors that delay message delivery. These will be discussed in more detail later.

The Corps Tac makes the first allocations of corps support resources according to plan by external message input. This allocation includes corps artillery, corps helicopters and the close air support that has been assigned by the Air Force. These resources will go to division during the specified time intervals unless there is a reallocation by corps (and by the Air Force for air resources). When additional resources are required above those allocated to a division, a request is made by the division to corps. Such a request can be initiated by an external message or by the force ratio at division exceeding a user-specified value. The division also supplies Corps Tac with spot reports on the attrition suffered by the division. If the appropriate random is on, these reports will be increased or decreased by a random amount for each report function that is the same for all items in the weapons type list. The division also sends spot intelligence reports of attrition of the opposing Red forces. These may be randomized as Blue's are randomized.

The information on which Corps Tac makes decisions is thus different from that at division, since reports on friendly or enemy losses will be delayed by at least one time interval and may be in error by the random factor(s). Based on the information received, a "current" list of the friendly and enemy opposing units is maintained. This list is used to provide the basis for the calculation of the local or division force ratio. The force ratio calculation is based on the weighted sum of the number of weapons on each side where the weighting factor is an input by the user of the model. The ratio of the Red to Blue weighted sums is the value of the force ratio that is used. The user can specify different weighting factors to represent different decision criteria. The allocation of corps resources is such that requests from the divisions (or armored cavalry regiments) are sorted by force ratio from most unfavorable to the most favorable. For CAS and helicopters, the requesting units will be provided a normal (nominally four) flight unless the corps has a reduced amount of resources available. In case of reduced availability, the corps will send a reduced number as long as that reduced number exceeds the minimum specified by the user (nominal value, two). For corps artillery, the corps support will be sent to the requesting unit whose force ratio has the highest Red/Blue value and is above the user artillery force ratio input.

The "action models" are to represent aspects of the military combat and support operations which affect the C3 system and which are affected by that system. The representation of ground force engagement processes that are included in the current version of the model uses a matrix method of calculation of the attrition processes. This method is similar to the dynamic model used in the total force capability assessment (TFCA) games. The matrix method allows for the calculation of attrition by fires of N Blue weapons on M Red weapons with allocation of fire and engagement rates according to input data.

Losses in the C3EVAL model are calculated by equation 1.

$$1. \quad \begin{aligned} \mathring{B}_i &= K_{ji}^{rb} \quad R_j \\ \mathring{R}_j &= K_{ij}^{br} \quad B_i \end{aligned}$$

where i is the number of different Blue weapon systems

B_i is the number of Blue weapons of type i

$\overset{\circ}{B}_i$ is the number of losses of type i

j is the number of different Red weapon systems

R_j is the number of Red weapons of type j

$\overset{\circ}{R}_j$ is the number of losses of type j

K_{ji}^{rb} is the kill potential of Blue by Red

K_{ij}^{br} is the kill potential of Red by Blue

The kill potential matrices are calculated by equation 2.

$$
\text{2.} \qquad
\begin{aligned}
K_{ji}^{rb} &= E_j^{r} \quad A_{ji}^{rb} \quad p_{ji}^{rb} \quad D_i^{pb} \\
K_{ij}^{br} &= E_i^{b} \quad A_{ij}^{br} \quad p_{ij}^{br} \quad D_j^{pr}
\end{aligned}
$$

where E_j^r, E_i^b are the engagement rate vectors

A_{ji}^{rb}, A_{ij}^{br} are the allocation matrices

p_{ji}^{rb}, p_{ij}^{br} are the probability of kill matrices

D_i^{pb}, D_j^{pr} are the defensive factors for the unit postures

The allocation matrices are calculated from predicted allocation matrices, estimates of the distribution of the foe's weapon strengths and modifications due to actual distributions as shown in equation 3.

3.

$$A_{ji}^{rb} = \frac{\overset{*}{A}{}_{ji}^{rb} \; B_i \; / \; \overset{*}{B}_i}{\sum_{i=1}^{mb} \overset{*}{A}{}_{ji}^{rb} \; B_i \; / \; \overset{*}{B}_i}$$

$$A_{ij}^{br} = \frac{\overset{*}{A}{}_{ji}^{br} \; R_j \; / \; \overset{*}{R}_j}{\sum_{j=1}^{mr} \overset{*}{A}{}_{ij}^{br} \; R_j \; / \; \overset{*}{R}_j}$$

where $\overset{*}{A}{}_{ji}^{rb}$, $\overset{*}{A}{}_{ij}^{br}$ R_j are the predicted allocation matrices

$\overset{*}{B}_i$, $\overset{*}{R}_j$ are the estimates of the distributions of strengths

The combat system types are symmetric for Red and Blue: APC, AFV, TANKS, LT ANTITANK, HV ANTITANK, MORTARS, ARTILLERY, HELICOPTERS, AAA, SAMS and CAS. The initial strengths for all combat units are input from the scenario data and may be increased or decreased by the user at any game time. An aggregated estimate of a combat situation is formed by the force ratio calculation shown in equation 4.

4.

$$FRB = \frac{\sum_{j=1}^{mr} R_j \; W_j^r}{\sum_{i=1}^{mb} B_i \; W_i^b}$$

where FRB is the Red to Blue force ratio

W_j^r, W_i^b are user-specified weighting factors

Unit posture and engagement rate are initially set by scenario data and can be reset by the user at any time. The types in use are attack, deliberate defense, withdraw and reserve. The engagement rate types are day, night and reduced visibility.

CAS may be entered into the combat matrix by the user for the Red side only. This represents a continuing level of support by frontal aviation. The user may schedule preplanned Blue CAS sorties in scenario data. Actual arrival of preplanned Blue CAS depends on timely receipt at the WOC of a coordination message from Corps Tac and the current availability of aircraft.

Combat units will request support whenever their model truth force ratio of Red to Blue exceeds a limiting value. If the request message is received by Corps Tac, it is included in the allocation of available general support artillery and helicopters and for immediate CAS approval. This allocation process is a function of Corps Tac's perceptions of its subordinates' combat status and the availability of resources.

The air base model contains representation of a WOC and a Control and Reporting Center (CRC). The WOC controls the allocation of available aircraft on the ground at the air base to the requests for air support that it has received via messages. The CRC receives control of sorties once they are airborne. The CRC process calculates the time over target, modifies the appropriate unit combat matrix to include the sorties, calculates attrition to the aircraft en route and schedules them for control by the WOC after they land after accounting for attrition in the combat area. Only one mission type is flown in the present configuration, CAS/battlefield air interdiction (BAI).

The model has random processes which can be turned on or off at the user's discretion. Random impact may cause seven different error types. These errors may be a function of NODE, MESSAGE TYPE, COMMUNICATION PATH or WOC operations. Random effects are based on a data structure having a random distribution number (RDN) set to the distribution type number. If the RDN is zero, there is no random effect. If the master random flag is off, there is no random effect. If the master flag is on and RDN equals n, then distribution n in the PARAM data file is used. Each distribution has a type number n and 11 real value parameters to be selected by a uniform (0:1) random number draw. The distributions may look like:

1	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
2	0.	0.	1.	1.	2.	2.	2.	2.	2.	2.	2.
[illegible]	.4	.6	1.	1.	1.	1.2	1.4	1.8	2	2.5	3.5

The algorithm to set the index for the parameter is:
INDEX = MAX(10,IFIX(10.*(RND+.10001)))

1) CAS to Target: The assignment of a target (combat support unit) for CAS sorties may be in error. This is indicated by RDN in the WOC data structure. If the parameter selected is zero, no error occurs; if the parameter is 1. the sortie is placed on airborne alert; and if greater than 1. the sortie is sent to the wrong target (if other units have requests on file) or on airborne alert. This action is done by the WOC process.

2) Partial Message Received: Any node may receive a partial message. This is indicated by the RDN1 in the RULE data structure that processes the input message. If the parameter selected is zero, then no error; 1., the message sender is requested to repeat the message; and greater than 1., the message is thrown away. This is done by the message receiving process.

3) Message Communication: Any path between two nodes may lose a message. This is indicated by RDN in the NODE:LINK data structure. If the parameter selected from that distribution is zero, then no error, and greater than or equal to 1. the message is lost. This action is done by the message SEND routine.

4) Message Length: Any message created by any node may have its length (communications path capacity) changed up or down. This is indicated by the first RDN in the NODE:RANDOM data structure. The length of each message created is multiplied by the parameter selected for that message. Note the result may be zero or so large that the message can never be sent. This action is taken by the create message routine.

5) Message Delay: The time required to create a message by any node may be incremented by the second RDN in the NODE:RANDOM data structure. The parameter selected is added to the standard creation time. This action is done by the create message routine.

6) CAS Request Delay: The time that a request for CAS is initiated may be incremented by any combat-level node. This is indicated by the third RDN in the

NODE RANDOM data structure. The parameter selected is added to the standard creation time. This action is done by the COMBAT routine.

7) Message Content: Any message with actual content may have its content modified by any node that handles the message (but not by alternate nodes that communicate the message but do not "handle" it). This is indicated by the RDN2 in the RULE data structure that processes the message. Note that this means that message content may be corrupted by the sending and receiving nodes. All values in the message are multiplied by the parameter selected. This action is done by the message create and message received routines.

III. DATA

A. INTRODUCTION

The objective of this chapter is to describe the approaches to the development of key data elements for the C3EVAL model. Data for the representation of combat interactions at the level of probabilities of kill and rates of fire will not be considered here. Neither will the required data for force size and composition be considered. These data are not included here since it is assumed that they are available from regularly used models and analyses. It is recognized that some adjustment will be necessary to account for differences in time intervals used, level of aggregation and other model factors.

The first part of the discussion will be on the development of the decision rules that cause the creation and transmission of messages. A brief examination of the estimation of communication path capacities follows.

B. CREATION OF THE COMMAND AND CONTROL HIERARCHY

The command and control (C2) hierarchy in the model represents the command posts and the communications paths between those nodes. The first step in the process is to establish a node-type numbering scheme. In the data currently in the model, three-digit numbers are used for ground force and higher echelon command posts and four-digit numbers are assigned to Air Force units. The system currently in use is as follows:

250 Regiment
300 Division
400 Corps Main
450 Corps Tactical
490 Corps Rear
495 Corps Supply
500 CENTAG (Central European Army Group)
525 National Supply
550 USAREUR (US Army Europe)
600 AFCENT/AAFCE (Allied Forces Central Europe/Allied Air Forces Central Europe)
650 USEUCOM (US European Command)
700 SHAPE (Supreme Headquarters, Allied Powers Europe)
5000 ATOC (Allied Tactical Operations Center)
6000 4ATAF (4th Allied Tactical Air Force)
6500 USAFE (US Air Force Europe)
7000 WOC (Wing Operations Center)

Whenever a node is assigned a number, then that node will perform the functions that are assigned to that number. For example, if another division is added as a 300 designated node, then that node will perform those functions that have been assigned to other 300 number-type nodes. If there are divisions that perform their functions in a different manner, as with the divisions of a different nations acting in accord with a different doctrine, then that number-type division should be denoted differently, as, for example, number 305.

When a node is created, the model user must specify its communications connectivity with other nodes and whether the given node is subordinate or commander of the related node or just adjacent. The types of communication paths connecting two nodes must also be specified. Type means a specification as to whether the path is for voice, data, secure, non-secure, dedicated (e.g., for intelligence purposes only) or other type.

C. DEVELOPMENT OF RULES FOR C3EVAL

The rules in the C3EVAL model represent the processes by which messages are created and transmitted at command posts (nodes) in the C3EVAL model. The schematic for the standard node processes is discussed in Chapter II, Section F, and is shown in Figure II-3 Messages are generated at a node by a rule. Each rule is assigned a four-digit number. The rule, in the standard rule process, is initiated with the input of one or more input messages that also are designated by four-digit numbers. The "action" of the rule results in the production of one or more messages that are sent (according to the rules) to one or more nodes.

It is useful, in the rule/message development process, to use a schematic of the rule message flow as shown in an example in Figure III-1. The case shown is for an Operations Incident Report from the Commander of 4ATAF. The lower number in the first box on the left is the designator for the Allied Tactical Air Force (ATAF). The rule for generating the message is 6532. For convenience, messages originating at the ATAF were chosen to be 6500 or greater. The rule generates the message 6532, which has been assigned the same number as the rule which generates it. This message is sent to AAFCE (6000) with an information copy to USAFE (6500). At AAFCE rule 6305 generates a message number 6305 sending the information on to AFCENT (7000). Neither AFCENT nor USAFE generate a new message immediately based on the 6532 or 6305 message. For

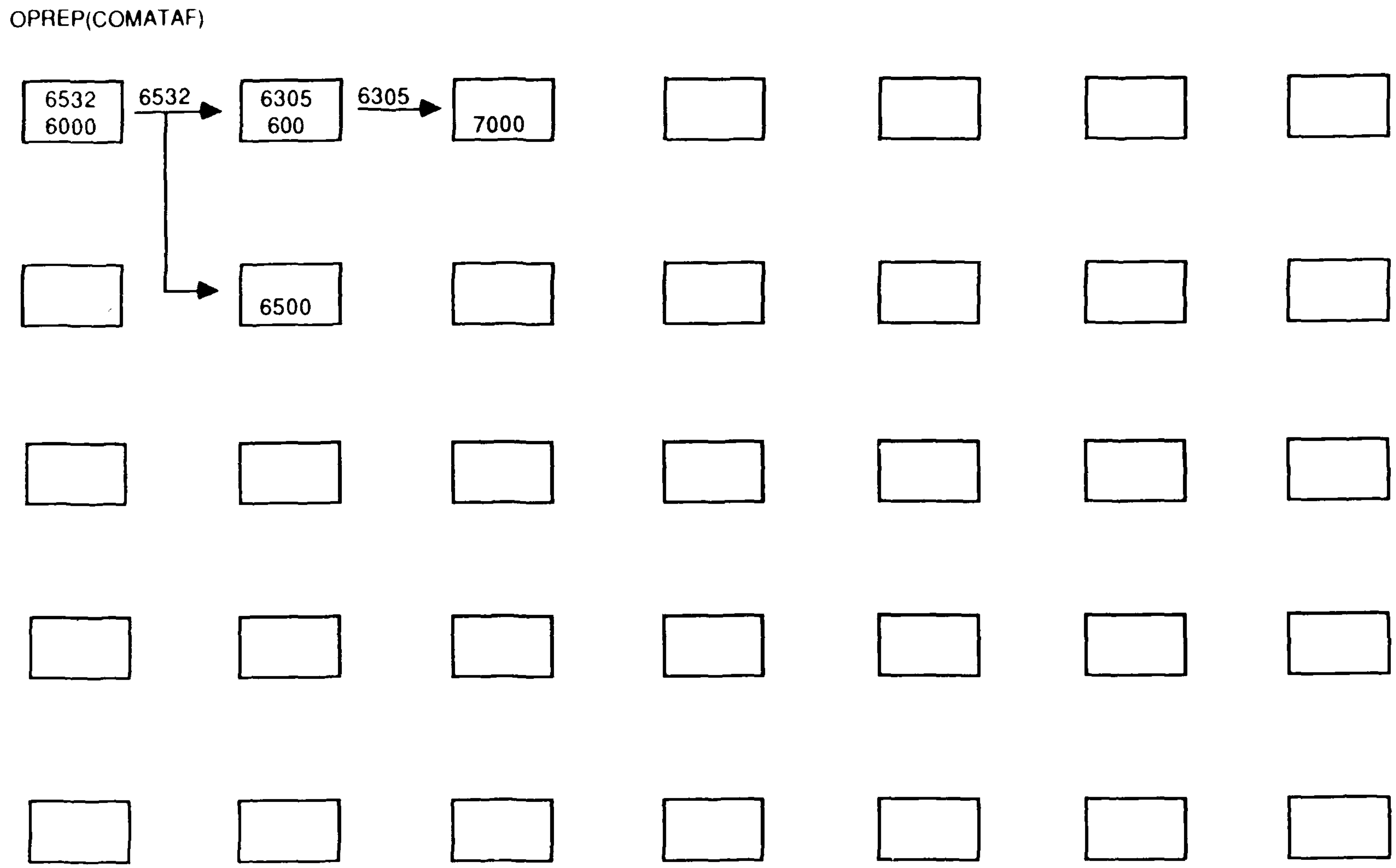


FIGURE III-1. EXAMPLE RULE/MESSAGE FLOW

many messages the rule/message flow is considerably more complex. The development of a diagram of this type assists the rule developer in the process of rule development and allows that person to keep track of the development process.

Some of the rules/message processes are created periodically, by external (scenario designated) command, at a time t by a random draw or by a combat event. For these rule/message processes the triggering rules vary somewhat. In general, the first step in the process is to identify the specific source that will initiate a message.

The rules for the command post or node for messages that are created at that node as the result of the receipt of a message from the INPUT message file. There are three sets of data in the node rules. Each set starts with a comment line and a header line. The comment line identifies the type of set (RULE, MSGIN, MSGOUT) and can log the purpose, version, date or other relevant information concerning the data set. The header is intended to document the data elements and to indicate the element location on a data line. The data lines must be followed by a line with a zero in column 6. The RULE data format is (I5, I10, 3I5, 2X, 3A4). The variables read are:

RNO: Rule number--assigned by the user. The rule number can generally be the same as the message number. Where feasible, the rule number can be chosen to have some relationship with the node number. For example, a rule being used by a division denoted by 300 can be numbered 3010. Care must be taken that each rule is uniquely numbered.

OTYPE: Type of unit that uses this rule, i.e., 300 for a US division.

TIME: Number of time increments required by this rule, i.e., does it take a one-half hour increment for the staff to prepare the message. If specific data are not available for this number, it is generally possible to make a judgment based on the length and content of the message. Discussion with military officers with field experience can provide a measure. Data from training exercises is also useful.

MININ: Number of input messages before a rule can start. For example, a corps report to echelon above corps (EAC) may require three input messages, one from each subordinate division.

FLAG: Periodic time increment to repeat this process, =0 is non-periodic. If, for example, a report is to be made three times a day, the process would nominally be repeated every eight hours, or 16 time intervals with the current data selection.

START TIME: The time at which the periodic time increment given in the previous column begins. If random is on and a periodic time increment is given and no start time is given, a random number will be used to determine when to send the first message.

COMMENT: Used to document the rule. Generally the name of the message being generated.

The variables read in a MSGIN data element format are:

RNO: Rule number--the same as in the previous data set.

ITYPE: Type of unit that sends this message. The number of the unit that transmits the message that triggers the RULE being considered.

MSG: Message type to activate the RULE being considered.

AGE: Number of time increments that this data is valid. This age will be set by the time when an update is expected or by the expected life of the information, e.g., information on moving units will clearly become obsolete as time passes and the unit moves to a new location.

USE: Message use limit, if 0 used only once.

COMMENT: Used to document this message data. It will usually be the name of the message.

The variables read in a MSGOUT data element format are:

RTNO: RULE NUMBER. The same as previous used.

DTYPE: Type number of unit that receives this message. A separate line is written for each receiver if there is more than one receiver.

MSG: Message type. The number of the message that is to be received by the receiving unit.

PRI: Message priority. Establishes order in which messages will be sent. There are three priority levels available.

LNK: Communications link type. Type is voice, secure voice, logistic net or other. This is the preferred link.

CAP: Communications capacity require to send the message in characters contained in the message.

LNK: Communications type for first alternate link.

CAP: Capacity required to send message over this type of communications link. For example, if voice is an alternate to TTY, then additional capacity may be required.

LNK: Communications type for second alternate link.

CAP: Communications capacity required for second alternative link to send this message.

CMD: =1, restricts message to commander only.

OPF: =1, program produces network trace.

ALTD: Type of unit for first alternate receiving node. If the message cannot be sent through any of the available links due to limitations on capacity, then the message will be routed through an alternative node for forwarding to the primary addressee.

ALTD: Type of unit for second alternate receiving node.

AGE: Number of time increments before message is deleted from the system

COMMENT: Used to document this message type.

Computer input forms have been prepared. These are shown in Tables III-1 through III-3. Tables III-4 through III-6 show completion of these forms for the Corps Tactical Headquarters (Corps Tac) node.

D. COMMUNICATIONS PATH CAPACITIES

The user specifies the communications that connect the nodes or command posts. There may be as many connecting paths as desired. They may be designated by characteristics (secure/non-secure, telephone, radio, telegraph or others) or by function (command link, operations link, intelligence link, logistics link or other). As indicated in the discussion of rule development, the user designates which communications paths the message is to be transmitted over in the rule development. It can thus be seen that the commander can preempt an operations path, for example, if the message has sufficient priority. If there is more than one communications link of the same designation between two command nodes, e.g., the commander has two radio-telephone links, these will be aggregated into one path. The capacities of the paths are denoted by the number of characters that can be sent over all the aggregated links in that path during the chosen time

Table III-1. RULE DATA FORM

RNO	O TYPE	TIME	MIN	FLAG	START TIME	COMMENT

Table III-2. INPUT MESSAGES REQUIRED TO INITIALIZE

RNO	I TYPE	MSG	AGE	USE	COMMENT

Table III-3. OUTPUT MESSAGES BASED ON DECISION RULES

NO	D TYPE	MSG	PRI	LINK	CAP	LINK	CAP	LINK	CAP	C	O	ALT 2	ALT 3	A	COMMENT

Table III-4. RULE DATA CAS MESSAGES AT CORPS

RNO	O TYPE	TIME	MIN	FLAG	COMMENT
4703	450	1	1	0	ASOC IAR
4701	450	1	1	0	ASOC IAR
4403	450	1	1	0	CORPS AIR
4400	450	1	1	0	CORPS AIR
4702	450	1	1	0	ASOC IAS

Table III-5. INPUT MESSAGES REQUIRED TO INITIALIZE

RNO	I TYPE	MSG	AGE	USE	COMMENT
4703	250	3000	2	0	IAR
4701	300	3000	2	0	IAR
4403	350	3400	2	0	IAR
4400	300	3400	2	0	IAR
4702	7000	7000	2	0	IAS

Table III-6. EXAMPLE OF OUTPUT MESSAGES

NO	D TYPE	MSG	PRI	LINK	CAP	LINK	CAP	LINK	CAP	C	O	ALT 2	ALT 3	A	COMMENT
4703	5000	3001	1	3	500	1	500	2	500	0	1	7000	450	2	IAR
4703	7000	3000	1	2	500	1	500	3	500	0	1	5000	450	2	IAR
4701	5000	3001	1	3	500	1	500	2	500	0	1	7000	450	2	IAR
4701	7000	3000	1	2	500	1	500	3	500	0	1	5000	450	2	IAR
4403	7000	3400	1	3	1500	1	1500	0	0	0	1	0	0	1	IAR
4403	500	3401	3	3	1500	1	1500	0	0	0	1	0	0	1	IAR
4400	7000	3400	1	3	500	1	500	0	0	0	1	0	0	1	IAR
4400	500	3401	3	3	500	1	500	0	0	0	1	0	0	1	IAR
4702	250	7000	3	3	500	2	500	0	0	0	1	400	300	4	IAR
4702	300	7000	3	3	500	2	500	0	0	0	1	400	400	4	IAS

interval. In the present version of the model, the time interval has been chosen to be one-half hour. The model does not require that characters be used, but it is essential that both path capacity and message length are expressed in the same units. The capacity of the path, if expressed in characters/time interval, will be set first by the capacity of the links aggregated in that path. In many cases, however, the capacity available for sending particular types of messages will be less than that permitted by the maximum data rate. An example of this is the use of a digital channel for transmitting voice. Based on available Army data, the maximum rate is 9,000 characters/half-hour. The transmission of teletype messages with no storage before transmission means that the transmission rate will be established by the typing rate.

For purposes of the model development, the basic capacities used are as follows:

Voice	9,000 characters/half-hour
Teletypewriter (TTY)	17,000 characters/half-hour
Data rate/channel (Army)	3.6×10^6 characters/half-hour
Data rate/channel (Air Force)	1.8×10^6 characters/half-hour

These data are taken from unclassified sources, and thus may not accurately reflect the actual capacities available.

The selection of capacities for the paths is based whenever possible on a doctrinal statement as to the resources available. The representation, for example, of division communications is a doctrinal system oased on US Army Field Manual FM 11-50, "Combat Communications Within the Division." This means that the data will not exactly reflect the division capabilities in the 5th Corps area since the actual communications are tailored to the specific division. The doctrine specifies the number of paths available for the Commander, Operations and Intelligence, for example, and indicates whether they are dedicated voice, TTY or other. Standard practice for the use of multichannel paths is also specified.

At corps the doctrinal capacities are also used. The scenario specifies that TRITAC (tri-service tactical communications service) equipment is available. The scenario also specifies the netting of the communications within the corps and the major paths to NATO commands. The paths for the model are determined primarily from the doctrine that indicates the paths available and their type for Commander, Operations and Intelligence. This means that paths available, for example, from the German Postal Telephone and Telegraph (PTT) are not specified.

Air Force communications paths were determined from Tactical Air Force Interoperability Group (TAFIG) documents. Path capacities were established primarily on the basis of the connections made with the specified nodes in the TAFIG documents. These are the available documented capacities and not necessarily those that are actually in use with US forces in Central Europe.

When specifying the capacities available at the higher levels of command (4ATAF, CENTAG, AFCENT/AAFCE and SHAPE), reference was made to available documentation. The capacities are best estimates assuming that the nodes are the wartime locations. It is appreciated that many of the communications paths are netted, but no specific allowance has been made for this in the data currently in the model. In order to establish the characteristics of the nets that are being used, a separate network model should be used to determine the necessary values for the aggregated paths used in C3EVAL and for the degradation to be used when wartime damage is postulated in the scenario. The assumptions about the paths that are available should be verified directly with the appropriate commands in Europe, if desired.

E. COMBAT DATA

The remaining data set to be considered is the combat data. For purposes of the development of the model, the units identified are fictitious. Generic data is used for equipment in the units. These data are available from unclassified sources. The data used for rates of fire, allocations of fire and probabilities of kill are also unclassified.

IV. DEMONSTRATION OF APPLICATION

A. INTRODUCTION

The principal features of the model have been described in Chapter II and the primary data inputs in Chapter III. The capabilities of the model can be inferred from this information and in more detail from the Programmers' Manual (Volume II). This chapter provides some representative results of possible applications of the model. All data used is unclassified, including the scenario that is used to establish the forces involved, the times of attack and types of defense and the primary external messages that are input. This scenario is described in the base case section. In Section C a number of alternative case studies is presented. Excursions from the base case demonstrate the effects of different capabilities of the model. The excursions do not include all possibilities since many are now available. All possibilities have been tested for proper operation. These test cases do not generally provide interesting case studies since they may use extremes of value to exercise the model. A matrix of available possibilities is included in Section D.

B. BASE CASE

The scenario is an unclassified representation of the first three days of a campaign in Central Europe involving a conflict between US and Soviet forces. The forces used are fictitious units whose composition is representative of forces that could become engaged. Only conventional engagements are considered.

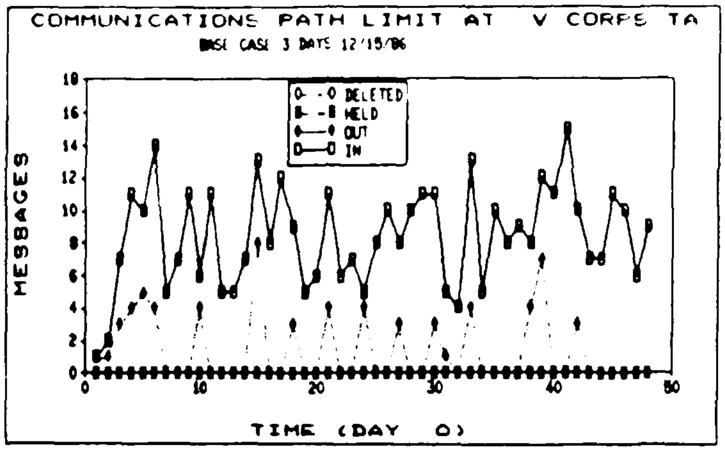
The base case highlights the significance of events that are shown in the results. In the base case the only random events introduced are those which trigger the generation of routine messages. Note that these messages are without content, i.e., they have a name, address, priority and a length requiring the use of a certain capacity of the communications paths. In the base case the corps support in artillery and helicopters and air force close air support (CAS) occurs according to plan or as input to the scenario. The force ratio triggers that would cause requests for corps support and/or air support are set such that none of the support is provided.

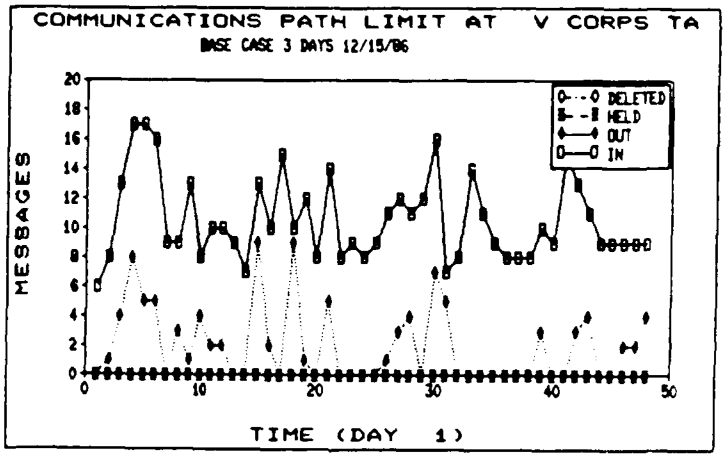
A more complete record of the base case is provided here in order to have a more complete set of results for comparison with the excursions. This set of graphics provides an example of the output that is readily available to the user. The first set of graphics is the "COMMUNICATIONS PATH LIMIT" for V Corps Tac (Figure IV-1) for the first day (Day 0). The subtitle "Base Case 3 days 12/15/86" is a comment the user inserts to identify the run and indicates that this is the base case of a three-day war run on December 15, 1986 Comparisons with alternative cases will show some variation due to the randomness of the routine messages. Figure IV-1 also provides the Corps Tac communications for the second and third days. The communications traffic into Corps Tac increases on the second day since more of the forces are engaged. There is little change in the general character of the input and output message summaries. Detailed information about specific messages is available (but is not shown here). One example of the Output and Input messages for Central European Army Group (CENTAG) is shown for the first day (Day 0) in Figure IV-2. There are no deleted or held messages, since there are no constraints imposed on the communications paths or on the capability of the command nodes to accomplish their tasks.

The forces involved in the scenario are a US Armored Cavalry Regiment (ACR) and three US divisions facing a strong Red attack. The fighting begins at 0730 (Time 3) on Day 0 with the 201st ACR as a covering force. Corresponding to the message record for Corps Tac, there are similar records available for the ACR and the US divisions. Figure IV-3 shows the message histories for the three days for the 52nd Mechanized Division (MD), 23rd Armored Division (AD), 20th MD and the 201st ACR. Only the first day is shown for the 201st ACR since that unit withdraws from combat part way through the first day, as described in the scenario. The 20th MD does not engage until the third day, so the first day is omitted.

The results of combat activities of the 201st ACR are shown in Figure IV-4 for the first day. The initial engagement rates are for daylight. The 201st ACR is in a delaying posture while the Red forces are attacking. The ACR is facing six Red regiments, four motorized rifle regiments (MRRs) and two tank regiments (TRs). At Time 5, or 0830, the enemy force is identified as consisting of the 68th, 69th, 19th and 20th MRRs and the 55th and 56th TRs. This condition remains constant until 1700 (Time 22) when both sides' engagement rates are lowered to reflect night operations.

At 2100 (Time 30) the Red forces in the north (Figure IV-5) are identified as the 127th Motorized Rifle Division (MRD) and the 17th Tank Division (TD). The Red force in the south is the 120th MRD. At 2130 (Time 31) the 201st ACR hands off the battle in the





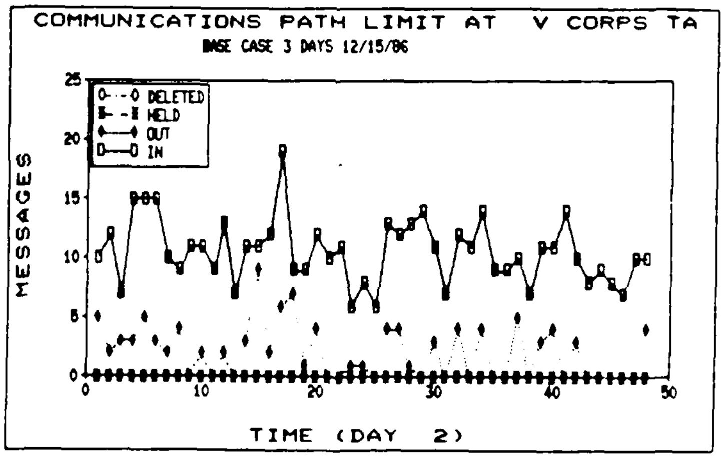


Figure IV-1. MESSAGES FOR CORPS TAC, DAYS 0, 1 AND 2

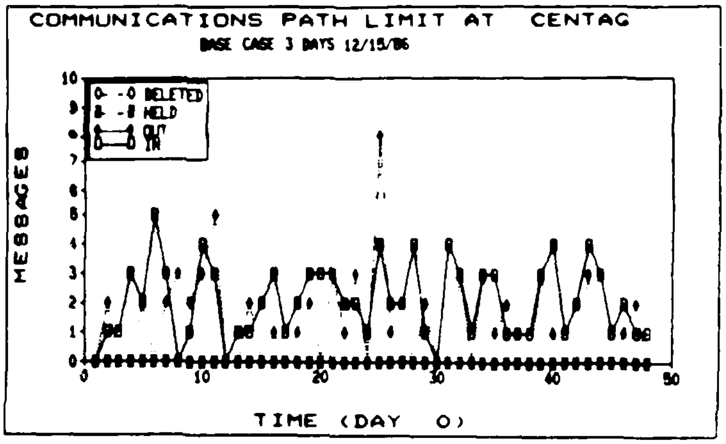


Figure IV-2. MESSAGES FOR CENTAG, DAY 0

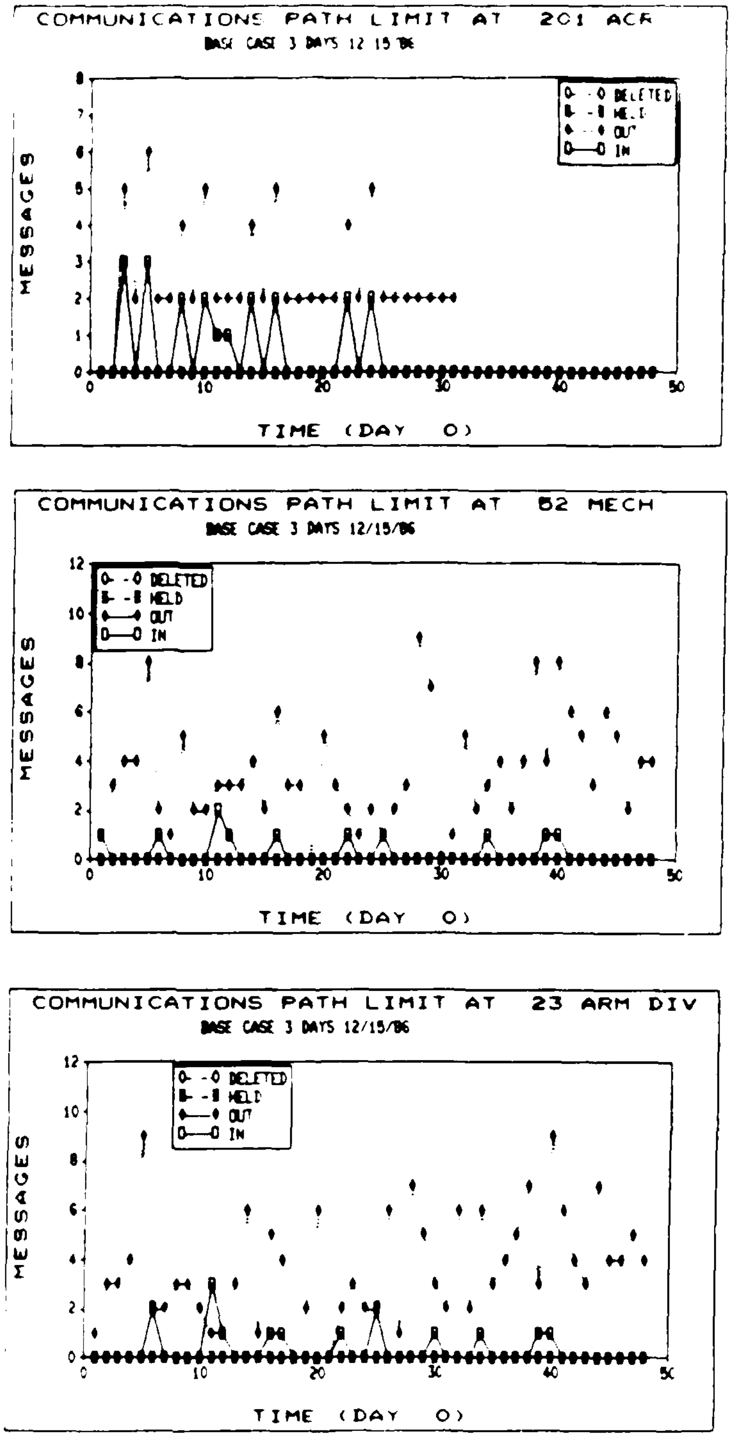
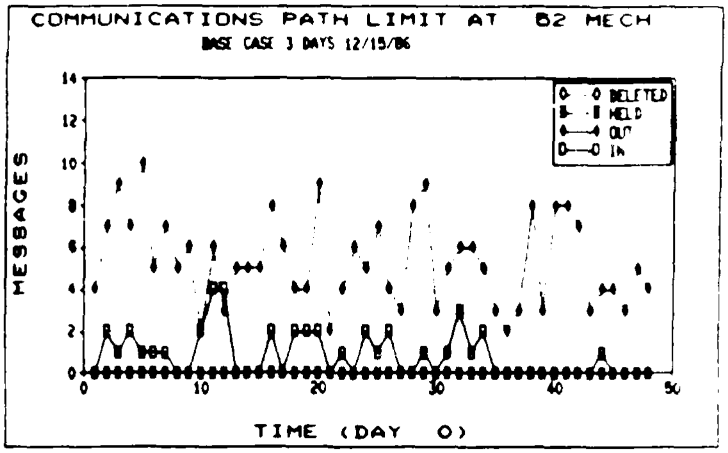
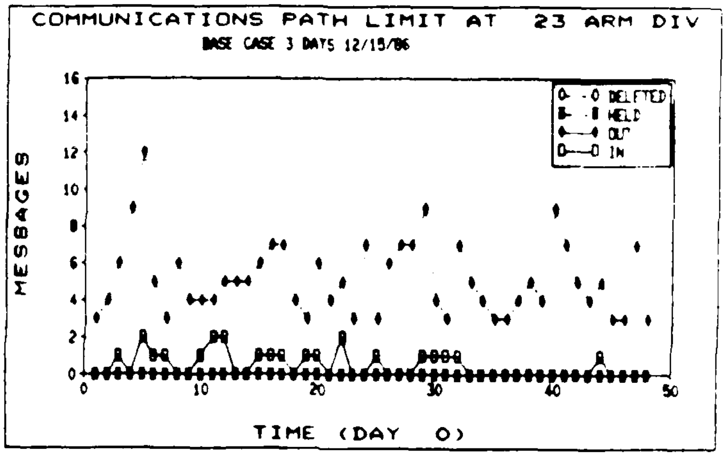


Figure IV-3. MESSAGES FOR THE ACR, MDS AND AD, DAYS 1 AND 2 (Continued)





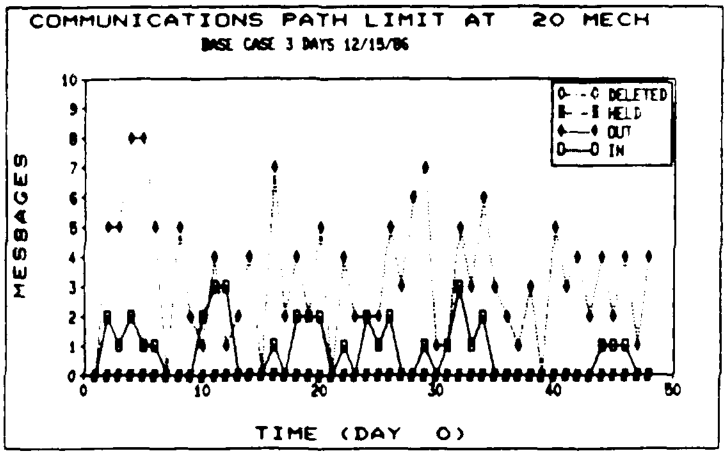


Figure IV-3. (Continued)

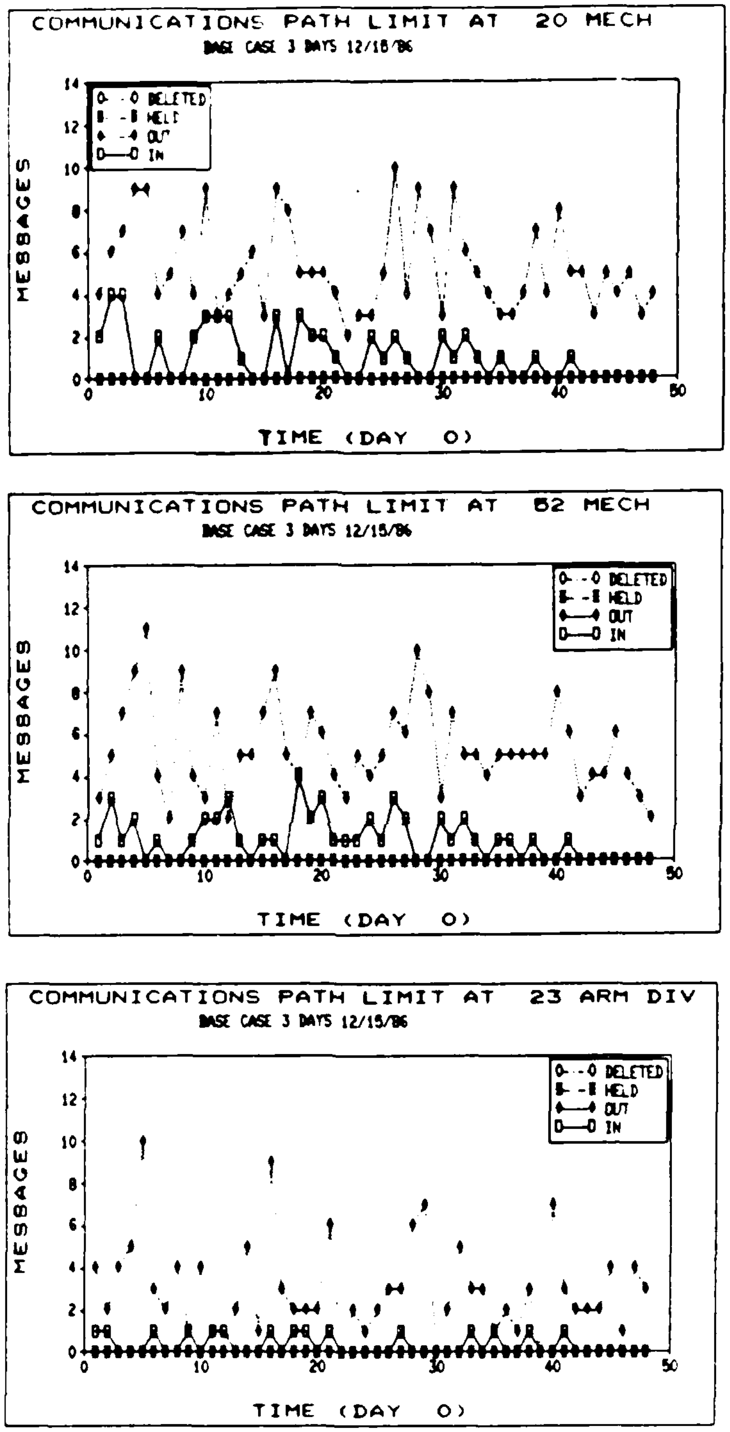
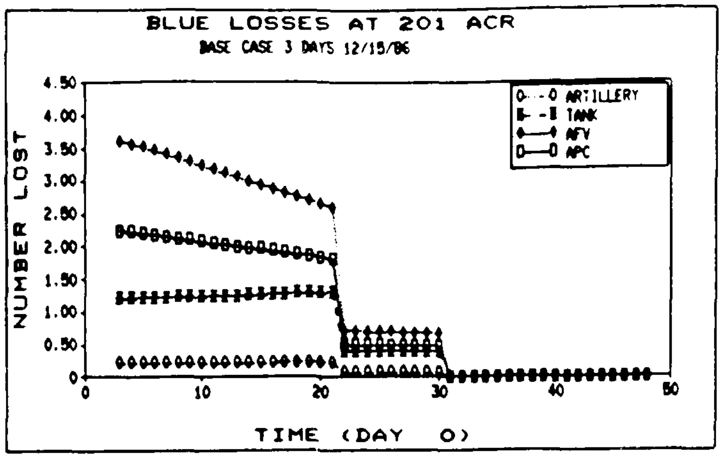


Figure IV-3. (Concluded)



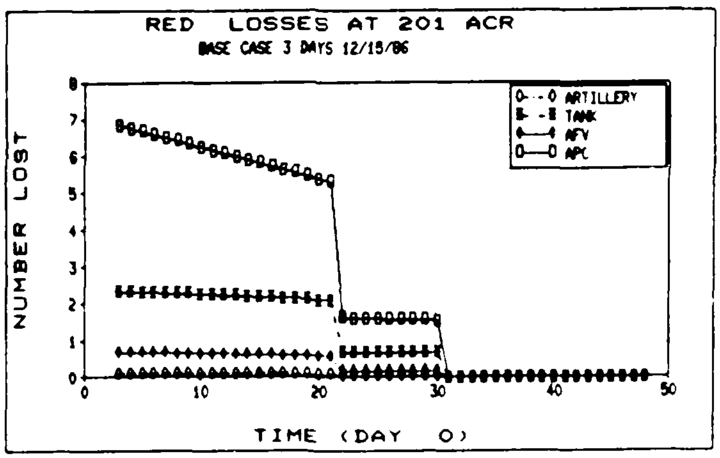


Figure IV-4. BLUE AND RED (B/R) COMBAT LOSSES AT THE 201ST ACR, DAY 0

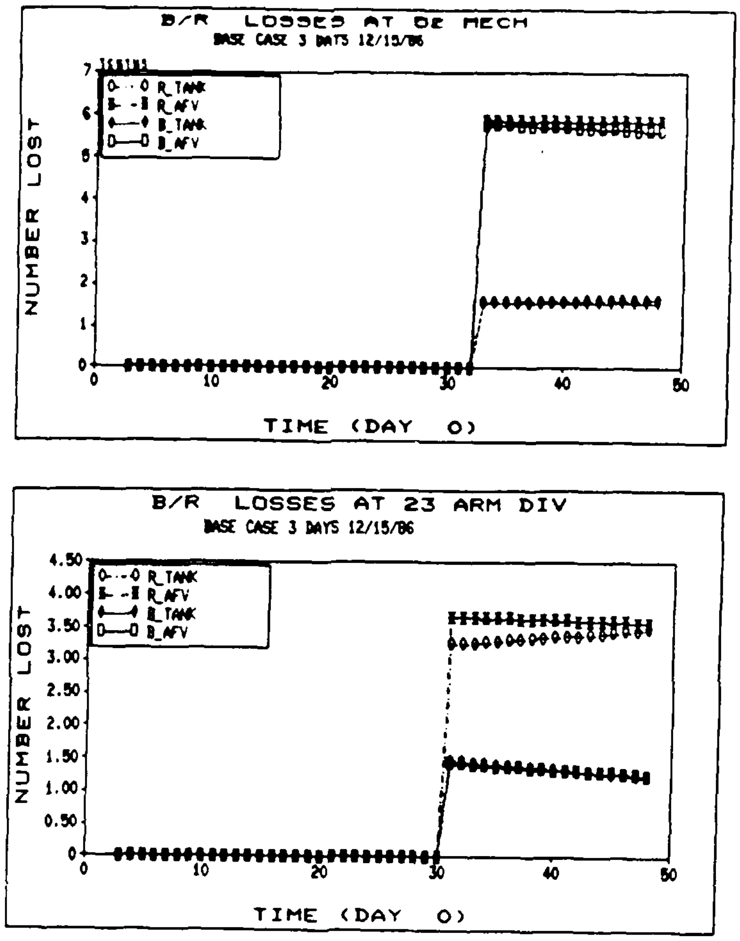


Figure IV-5. BLUE AND RED (B/R) COMBAT LOSSES AT THE 52ND MD AND THE 23RD AD, DAY 0 north to the US 23rd AD and at 2230 in the south to the US 52nd MD. The main Red attack is in the north so the 127th MRD and the 17th TD are in the attack posture while the 23rd AD is in the active defense posture. In the south both sides are in a posture to "avoid a decisive engagement."

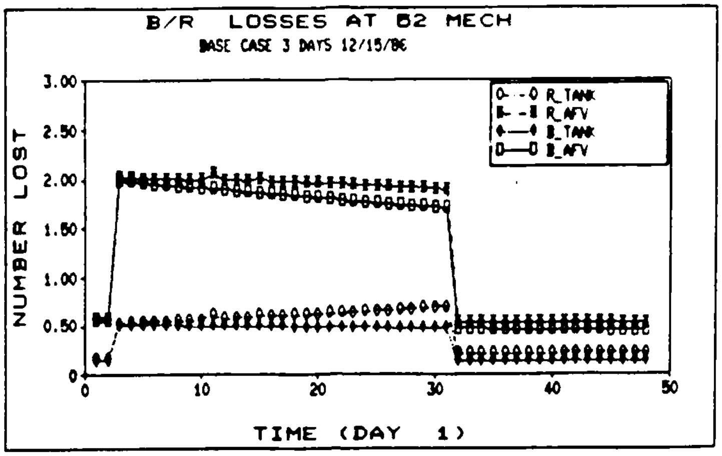
At 0730 Day 1 (Time 5) (Figure IV-6) both sides' engagement rates are increased to represent daytime operations. In addition, Red commits an additional TD, the 19th, in the north. Due to the strength of the attack, two flights of 4 aircraft are scheduled to support the 23rd AD and one flight of aircraft to support the 52nd MD. The messages to do this are started at Time 53 and Time 55. In addition, the 23rd AD is reinforced by an additional brigade at 0930 Day 1 (Time 55)

The 52nd MD receives another flight of preplanned CAS based on the messages starting at 1130. The next preplanned sorties support the 23rd AD from messages sent at 1430 and 1530. At 1830 Red commits an additional tank division to the attack on the 23rd AD. The attack is initially identified as consisting of two unknown tank regiments. Two and one-half hours later the new Red unit is identified as the 111th TD. At 2000 all units go to night engagement rates.

Daylight engagement rates begin at 0630 Day 2 (Time 97) (Figure IV-7). At this time the 23rd AD which has been facing the main attack hands off the battle to the 20th MD. Messages for preplanned CAS were send earlier (Time 93 and Time 94) so the aircraft arrive to support the hand off. The 20th MD is in a deliberate defense posture. At 0800 Day 2 the action between the 52nd MD and the 120th MRD becomes a contact-type engagement with low engagement rates on both sides.

At 1030 the Red commander commits the lead divisions of the 2nd Echelon Army against the 20th MD, who immediately goes to a delay posture. At 1100 the Red commander begins withdrawing the 127th MRD and the 17th TD from the attack. They are completely withdrawn by 1200.

The V Corps commander commits his reserve brigade to support the 20th MD at 1200 in response to the additional Red forces. The augmented 20th MD returns to an active defense posture. At 1230 the additional Red forces facing the 20th MD are identified at the 14th MRD and the 111th MRD. The 20th MD reports at 1400 that Red has withdrawn the 127th MRD and the 17th TD.



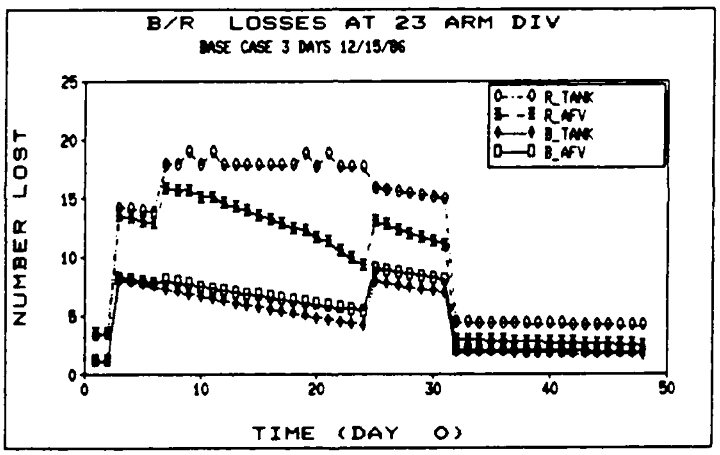


Figure IV-6. BLUE AND RED (B/R) COMBAT LOSSES AT THE 52ND MD AND THE 23RD AD, DAY 1

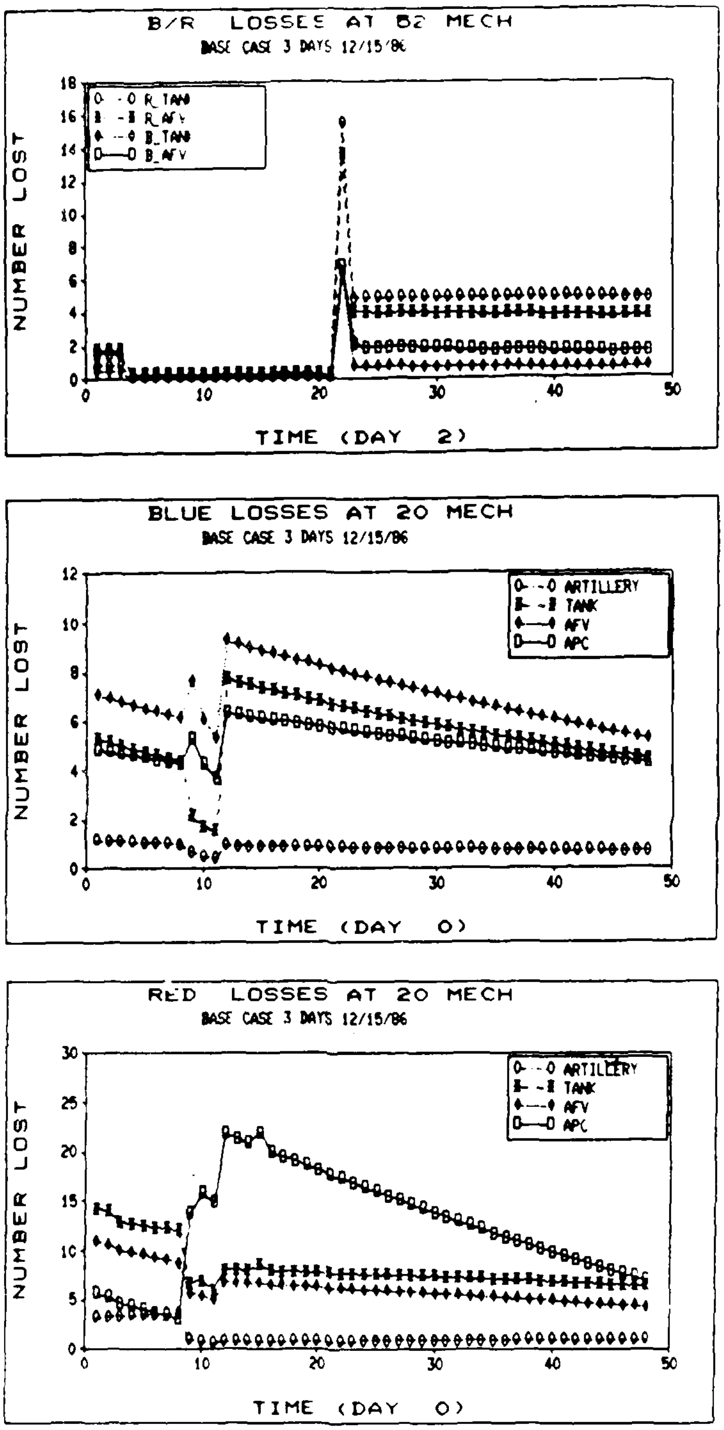


Figure IV-7. BLUE AND RED (B/R) COMBAT INTERACTIONS FOR THE 52ND MD AND THE 20TH MD, DAY 2

The V Corps commander plans to step up the pressure with the 52nd MD, so CAS is scheduled to arrive when the 52nd MD returns to an active defense. However, the Red commander commits an additional tank division against the 52nd MD at 1700. At 1730 all units go to night engagement rates and the Red commander commits two more tank divisions against the 52nd MD, forcing the 52nd MD to a delay posture. The Red commander begins to withdraw the 120th MRD from combat at 1800. At 1900 the 52nd MD identifies one of the new Red divisions as the 27th TD and reports it to V Corps. One-half hour later the 52nd MD identifies the other two divisions as the 110th TD and the East German 29th TD. The 52nd MD reports the withdrawal of the 120th MRD from combat at midnight. Figure IV-8 shows a graphic summary of losses by equipment type.

The results are also available in tabular form. Table IV-1 shows the summary of the messages received and sent by each command node. The chart also provides columns for messages held or killed (or lost). For the base case there are no messages in these categories. Also listed are the CAS and helicopter (HELO) sorties. These are all preplanned or the result of external or scenario input messages.

Table IV-2 provides summaries of the Blue and Red force strengths and losses and the perception of those strengths and losses at V Corps Tac based on the Corps Tac definition of the strength of the units.

C. EXCURSIONS

The first excursion to be considered is a case in which the trigger force ratios have been set so that when corps support resources are requested, artillery will be assigned first, helicopters second and CAS last These conditions can be altered by the force ratio (F/R) trigger selection.. The F/R triggers chosen are CAS F/R = 3.5, helicopter F/R = 2.5 and artillery F/R = 1.8. As described in Chapter II, if the trigger conditions are met and no corps support resource of one kind is available, the next "higher" kind will be requested. It should be noted that the values for the trigger force ratios are selected by the user and can be used to reflect different doctrines or different decision criteria by different commanders. Table IV-3 shows the summary output table for this case. A comparison with Table IV-1 notes that there are many more CAS missions and that helicopters have been requested in large numbers. The number of messages into Corps Tac has increased, as have those from the 52nd MD, 20th MD and 201st ACR. The output from Corps Tac has also increased.

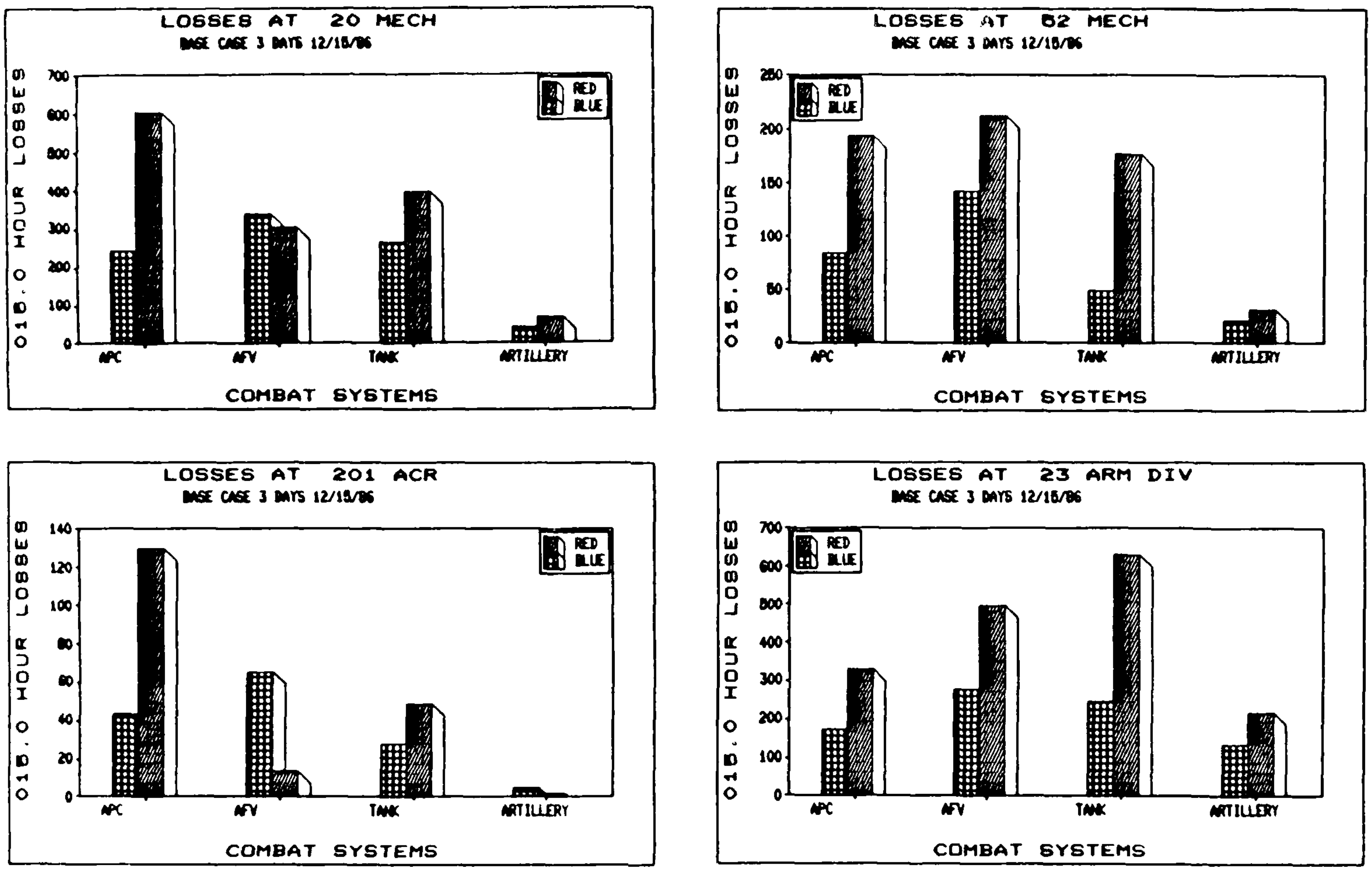


Figure IV-8. SUMMARY CHARTS FOR BASE CASE

Table IV-1. SUMMARY OUTPUT FOR BASE CASE (THREE DAYS)

SUMMARY OUTPUT AT TIME 144

UNIT	NUMBER	TYPE	COMMUNICATIONS LIMIT IN	OUT	HOLD	KILL	INPUT LIMIT IN	HOLD	KILL	OUTPUT LIMIT OUT	HOLD	KILL	SORTIES CAS	HELO
CAP	99	9999	0	0	0	0	0	0	0	0	0	0	0	0
V CORP SUP	23	495	0	6	0	0	0	0	0	6	0	0	0	0
USAFE	22	6500	103	2	0	0	103	0	0	2	0	0	0	0
USEUCOM	21	650	9	0	0	0	9	0	0	0	0	0	0	0
US SUPPLY	20	525	3	9	0	0	3	0	0	9	0	0	0	0
USAREUR	19	550	3	0	0	0	3	0	0	0	0	0	0	0
SHAPE	18	700	184	47	0	0	184	0	0	47	0	0	0	0
AFCENT/AAFC	17	600	833	455	0	0	833	0	0	455	0	0	0	0
VII CORPS	16	400	54	24	0	0	54	0	0	24	0	0	0	0
VII CORP TA	15	450	117	48	0	0	117	0	0	48	0	0	0	0
CENTAG	14	500	340	196	0	0	340	0	0	196	0	0	0	0
V CORP REAR	13	490	178	118	0	0	178	0	0	118	0	0	0	0
V CORPS TAC	12	450	1416	269	0	0	1416	0	0	269	0	0	0	0
52 MECH	9	300	101	680	0	0	101	0	0	680	0	0	14	0
WOC	8	7000	27	359	0	0	27	0	0	359	0	0	0	0
ATOC	7	5000	371	887	0	0	371	0	0	887	0	0	0	0
4ATAF	6	6000	911	785	0	0	911	0	0	785	0	0	0	0
23 ARM DIV	4	300	53	567	0	0	53	0	0	567	0	0	16	0
V CORPS	3	400	584	197	0	0	584	0	0	197	0	0	0	0
20 MECH	2	300	103	543	0	0	103	0	0	543	0	0	16	0
201 ACR	1	250	75	105	0	0	75	0	0	105	0	0	0	0

MSG-LOST 0 MSG-CONTENTS-CHANGED 0 MSG-REPEAT 0 MSG-PART-MISSING 0

CAS-WRONG-TARGET 0 CAS-ABORT 0

Table IV-2. SUMMARY OF UNIT STRENGTHS AS PERCEIVED AT CORPS TAC

COMBAT PERCEPTIONS BY V CORPS TAC OF 52 MECH AT TIME INCREMENT 144

ENG RATE BLUE 2

FCE UNIT	TYPE	ENG RATE	TIME
110 TH TD	225	2	132
29 TH TD EG	225	2	132
27 TH TD	225	2	132

	STRENGTH	LOSSES	STRENGTH	LOSSES
UNIT APC	186	78	105	133
UNIT AFV	246	132	385	197
UNIT TANK	275	45	804	162
UNIT ATANK LT	329	32	1003	32
UNIT ATANK HV	97	10	-16	43
UNIT MORTAR	105	4	40	14
UNIT ARTILLERY	95	18	242	28
UNIT HELICOPTER	40	1	0	0
UNIT AAA	20	0	46	2
UNIT SAM	32	1	324	9
UNIT CAS	13	0	0	0

COMBAT PERCEPTIONS BY V CORPS TAC OF 23 ARM DIV AT TIME INCREMENT 144

ENG RATE BLUE 2

FCE UNIT	TYPE	ENG RATE	TIME
127 TH MRD	325	2	78
19 TH TD	225	2	78
17 TH TD	225	2	78
111 TH TD	225	2	78

	STRENGTH	LOSSES	STRENGTH	LOSSES
UNIT APC	131	174	294	328
UNIT AFV	167	276	258	496
UNIT TANK	195	246	599	632
UNIT ATANK LT	353	39	1310	85
UNIT ATANK HV	39	30	28	56
UNIT MORTAR	130	36	82	26
UNIT ARTILLERY	75	133	162	216
UNIT HELICOPTER	51	6	-58	58
UNIT AAA	22	9	58	6
UNIT SAM	82	9	384	42
UNIT CAS	14	1	0	0

COMBAT PERCEPTIONS BY V CORPS TAC OF 20 MECH AT TIME INCREMENT 144

(Continued)

Table IV-2. (Concluded)

ENG RATE BLUE 3

FCE UNIT	TYPE	ENG RATE	TIME
19 TH TD	225	3	112
14 TH MRD	325	3	112
111 TH MRD	325	3	112
111 TH TD	225	3	112

	STRENGTH	LOSSES	STRENGTH	LOSSES
UNIT APC	19	235	271	589
UNIT AFV	-6	326	437	295
UNIT TANK	26	254	791	383
UNIT ATANK LT	88	61	1338	72
UNIT ATANK HV	54	45	33	99
UNIT MORTAR	63	29	99	45
UNIT ARTILLERY	13	39	331	65
UNIT HELICOPTER	31	12	-5	5
UNIT AAA	18	4	56	8
UNIT SAM	20	2	389	19
UNIT CAS	14	1	0	0

COMBAT PERCEPTIONS BY V CORPS TAC OF 201 ACR AT TIME INCREMENT 144

ENG RATE BLUE 2

FCE UNIT	TYPE	ENG RATE	TIME
155 TH MRD	325	2	5C

	STRENGTH	LOSSES	STRENGTH	LOSSES
UNIT APC	45	42	2C4	130
UNIT AFV	50	65	159	13
UNIT TANK	95	27	217	48
UNIT ATANK LT	45	8	352	8
UNIT ATANK HV	0	C	35	22
UNIT MORTAR	16	1	49	5
UNIT ARTILLERY	19	4	1C6	2
UNIT HELICOPTER	0	0	0	0
UNIT AAA	11	0	16	C
UNIT SAM	0	0	92	1
UNIT CAS	0	0	0	C

Table IV-3. SUMMARY OUTPUT FOR CORPS SUPPORT ON REQUEST FOR ARTILLERY, HELICOPTERS OR CAS

SUMMARY OUTPUT AT TIME 144

UNIT	NUMBER	TYPE	COMMUNICATIONS LIMIT IN	OUT	HOLD	KILL	INPUT LIMIT IN	HOLD	KILL	OUTPUT LIMIT OUT	HOLD	KILL	SORTIES CAS	HELO
CAP	99	9999	0	0	0	0	0	0	0	0	0	0	0	0
V CORP SUP	23	495	0	6	0	0	0	0	0	6	0	0	0	0
USAFE	22	6500	103	2	0	0	103	0	0	2	0	0	0	0
USEUCOM	21	650	9	0	0	0	9	0	0	0	0	0	0	0
US SUPPLY	20	525	3	9	0	0	3	0	0	9	0	0	0	0
USAREUR	19	550	3	0	0	0	3	0	0	0	0	0	0	0
SHAPE	18	700	242	42	0	0	242	0	0	42	0	0	0	0
AFCENT/AAFC	17	600	877	510	0	0	877	0	0	510	0	0	0	0
VII CORPS	16	400	54	24	0	0	54	0	0	24	0	0	0	0
VII CORP TA	15	450	115	48	0	0	115	0	0	48	0	0	0	0
CENTAG	14	500	395	244	0	0	395	0	0	244	0	0	0	0
V CORP REAR	13	490	181	112	0	0	181	0	0	112	0	0	0	0
V CORPS TAC	12	450	1472	388	0	0	1472	0	0	381	0	0	0	0
52 MECH	9	300	119	699	0	0	119	0	0	699	0	0	26	52
WOC	8	7000	34	365	0	0	34	0	0	365	0	0	0	0
ATOC	7	5000	369	888	0	0	369	0	0	888	0	0	0	0
4ATAF	6	6000	909	786	0	0	909	0	0	786	0	0	0	0
23 ARM DIV	4	300	52	563	0	0	52	0	0	563	0	0	16	0
V CORPS	3	400	580	198	0	0	580	0	0	198	0	0	0	0
20 MECH	2	300	108	556	0	0	108	0	0	556	0	0	28	12
201 ACR	1	250	115	133	0	0	115	0	0	133	0	0	4	95

MSG-LOST 0 MSG-CONTENTS-CHANGED 0 MSG-REPEAT 0 MSG-PART-MISSING 0
CAS-WRONG-TARGET 0 CAS-ABORT 0

A comparison of losses for Blue and Red at the 201st ACR is shown in Figure IV-9. When these are compared with Figure IV-4 it can be seen that the addition of corps support resources has made some significant differences. Generally the Blue losses are less and the Red losses greater. The abrupt rise in loss of Red when close air support arrives can be seen at the Time 20 interval. Another comparison is provided for Day 2 (the third day of combat) by an examination of Figures IV-10 and IV-7. The differences, including the effects of additional CAS, are apparent.

Two illustrations of the impact on message flow are given. The first is in Figure IV-11, which shows the message flow for Corps Tac for Day 2. A comparison with Figure IV-1 brings out the greater number of messages even though the peak flow in Figure IV-11 is no greater. A comparison of Figure IV-2 and Figure IV-12 of the message flows for CENTAG also indicates the greater message flow in the case in which corps support is requested. This is a reflection of the need to request additional air sorties and the need for additional reporting of activities.

A third excursion is the case in which the message input and output capability is reduced. This could be representative of a headquarters on the move. The time period over which the limit occurs is from Time 125 to Time 130, or between 1930 and 2200 on the third day or Day 2. The corps support resources are being allocated on request according to the rules and the corps perceptions, as in the immediately preceding case. Table IV-4 shows that the availability of CAS and helicopters has not changed even with the reduced Corps Tac capability during a three-hour period. The table indicates that there are messages delayed and killed at Corps Tac that were received and delivered under normal operations. These holds and kills are also evident in Figure IV-13 during the appropriate time intervals for Day 2. Since no change occurred in the combat attrition, none of these graphics is shown.

One way of representing the effects of electronic countermeasures (ECM) is to reduce the capacity of the vulnerable communications paths. For this example, the capacity of all communications paths between the divisions and Corps Tac (except courier) were reduced to 10 percent of their nominal value. In the example, corps support from artillery, helicopters and CAS is available on request, as in Case 2. Table IV-5 shows that the same total of helicopters and CAS arrived. The table also indicates that two messages were held at the 52nd MD. There were no discernible effects on the combat losses of either side.

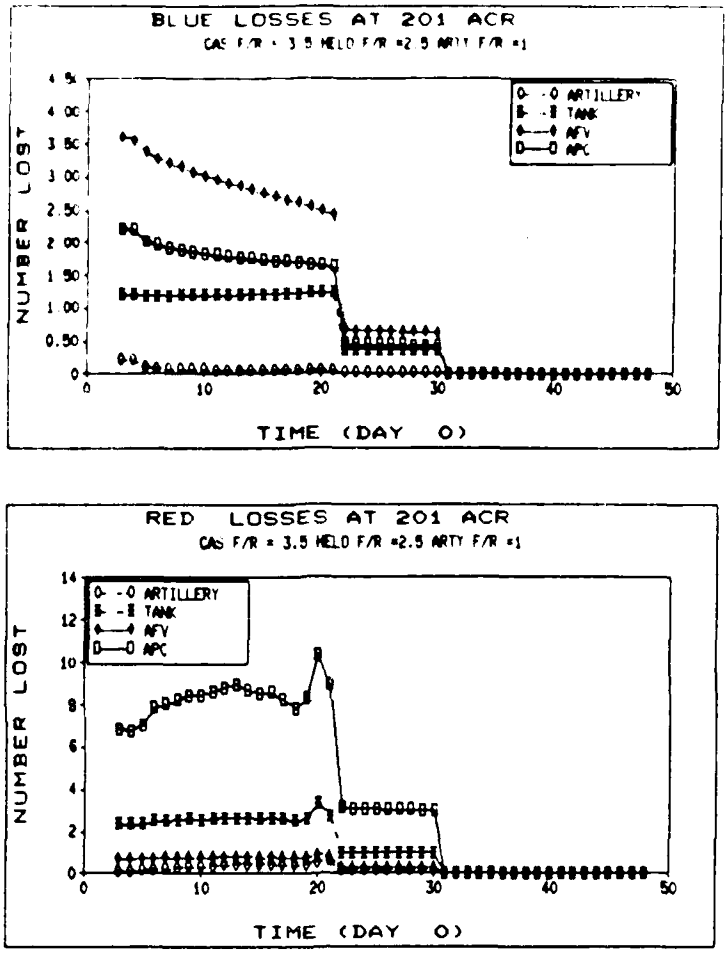
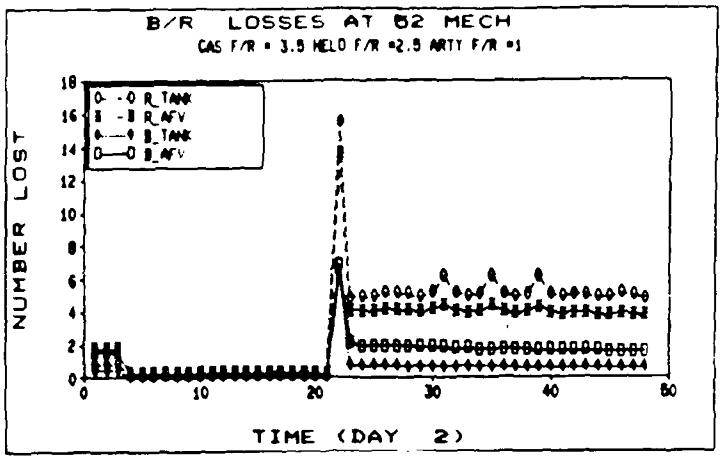
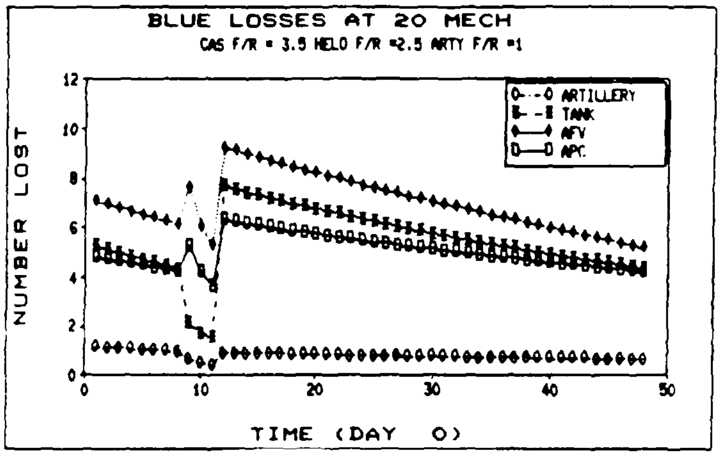


Figure IV-9. BLUE AND RED (B/R) COMBAT LOSSES AT THE 201ST ACR WITH CORPS SUPPORT RESOURCES, DAY 0





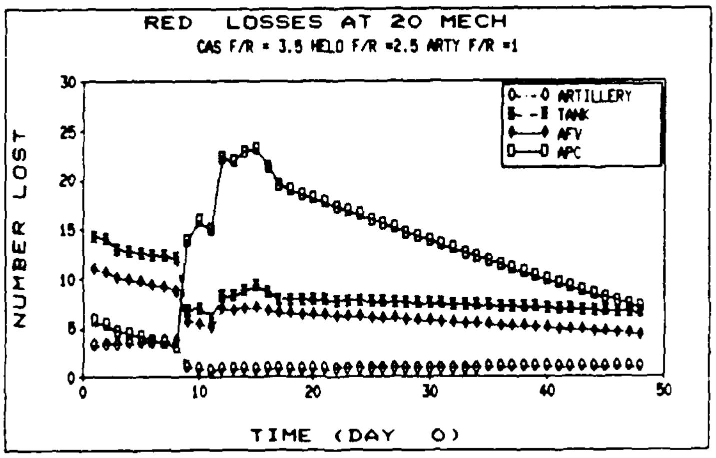


Figure IV-10. BLUE AND RED (B/R) COMBAT LOSSES AT THE 52ND MD AND THE 20TH MD WITH SUPPLEMENTAL CORPS SUPPORT, DAY 2

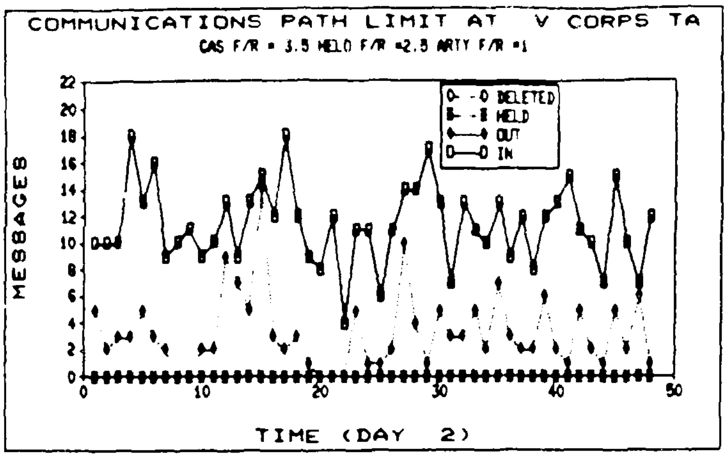


Figure IV-11. MESSAGE FLOW AT CORPS TAC WITH CORPS SUPPORT REQUESTS

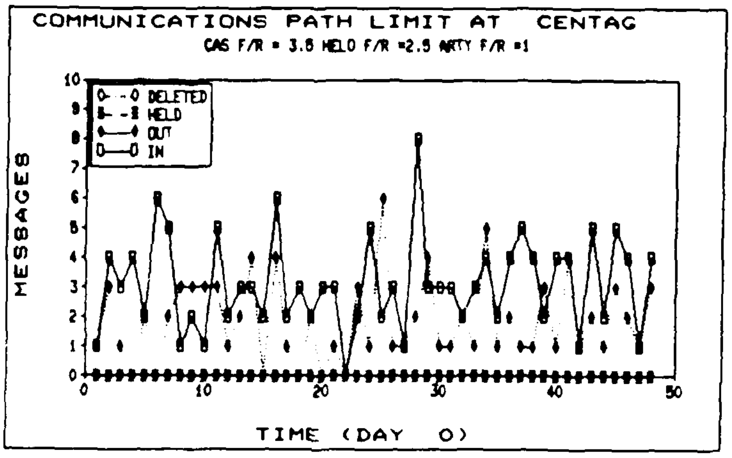


Figure IV-12. MESSAGE FLOW AT CENTAG WITH CORPS SUPPORT REQUESTS

Table IV-4. SUMMARY OUTPUT FOR LIMITED INPUT AND OUTPUT FOR CORPS TAC

SUMMARY OUTPUT AT TIME 144

UNIT	NUMBER	TYPE	COMMUNICATIONS LIMIT IN	OUT	HOLD	KILL	INPUT LIMIT IN	HOLD	KILL	OUTPUT LIMIT OUT	HOLD	KILL	SORTIES CAS	HELO
CAP	99	9999	0	0	0	0	0	0	0	0	0	0	0	0
V CORP SUP	23	495	0	6	0	0	0	0	0	6	0	0	0	0
USAFE	22	6500	103	2	0	0	103	0	0	2	0	0	0	0
USEUCOM	21	650	9	0	0	0	9	0	0	0	0	0	0	0
US SUPPLY	20	525	3	9	0	0	3	0	0	9	0	0	0	0
USAREUR	19	550	3	0	0	0	3	0	0	0	0	0	0	0
SHAPE	18	700	241	43	0	0	241	0	0	43	0	0	0	0
AFCENT/AAFC	17	600	879	507	0	0	879	0	0	507	0	0	0	0
VII CORPS	16	400	53	24	0	0	53	0	0	24	0	0	0	0
VII CORP TA	15	450	115	48	0	0	115	0	0	48	0	0	0	0
CENTAG	14	500	390	243	0	0	390	0	0	243	0	0	0	0
V CORP REAR	13	490	179	110	0	0	179	0	0	110	0	0	0	0
V CORPS TAC	12	450	1473	380	0	0	1459	1	13	373	0	4	0	0
52 MECH	9	300	117	701	0	0	117	0	0	701	0	0	26	52
WOC	8	7000	34	365	0	0	34	0	0	365	0	0	0	0
ATOC	7	5000	371	889	0	0	371	0	0	889	0	0	0	0
4ATAF	6	6000	908	787	0	0	908	0	0	787	0	0	0	0
23 ARM DIV	4	300	51	562	0	0	51	0	0	562	0	0	16	0
V CORPS	3	400	580	198	0	0	580	0	0	198	0	0	0	0
20 MECH	2	300	107	555	0	0	107	0	0	555	0	0	28	12
201 ACR	1	250	115	133	0	0	115	0	0	133	0	0	4	95

MSG-LOST 0 MSG-CONTENTS-CHANGED 0 MSG-REPEAT 0 MSG-PART-MISSING 0
CAS-WRONG-TARGET 0 CAS-ABORT 0

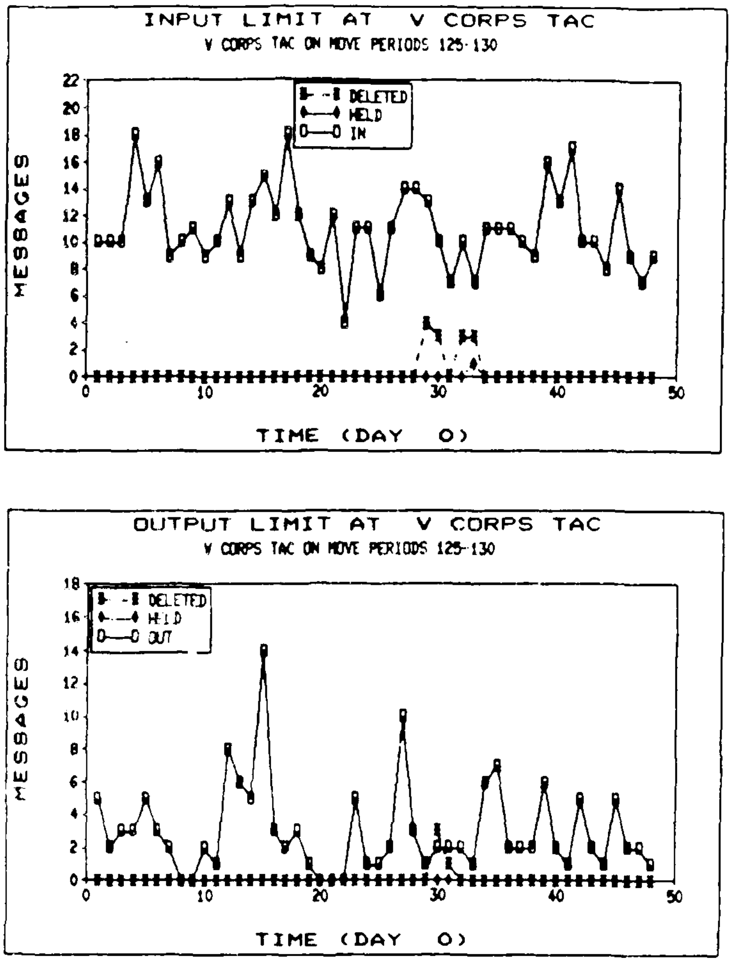


Figure IV-13. MESSAGE INPUT AND OUTPUT WITH CORPS TAC LIMITING

Table IV-5. SUMMARY OUTPUT WITH ECM

SUMMARY OUTPUT AT TIME 144

UNIT	NUMBER	TYPE	COMMUNICATIONS LIMIT IN	OUT	HOLD	KILL	INPUT LIMIT IN	HOLD	KILL	OUTPUT LIMIT OUT	HOLD	KILL	SORTIES CAS	HELO
CAP	99	9999	0	0	0	0	0	0	0	0	0	0	0	0
V CORP SUP	23	495	0	6	0	0	0	0	0	6	0	0	0	0
USAFE	22	6500	103	2	0	0	103	0	0	2	0	0	0	0
USEUCOM	21	650	9	0	0	0	9	0	0	0	0	0	0	0
US SUPPLY	20	525	3	9	0	0	3	0	0	9	0	0	0	0
USAREUR	19	550	3	0	0	0	3	0	0	0	0	0	0	0
SHAPE	18	700	241	44	0	0	241	0	0	44	0	0	0	0
AFCENT/AAFC	17	600	882	512	0	0	882	0	0	512	0	0	0	0
VII CORPS	16	400	54	24	0	0	54	0	0	24	0	0	0	0
VII CORP TA	15	450	116	48	0	0	116	0	0	48	0	0	0	0
CENTAG	14	500	394	246	0	0	394	0	0	246	0	0	0	0
V CORP REAR	13	490	130	112	0	0	180	0	0	112	0	0	0	0
V CORPS TAC	12	450	1472	388	0	0	1472	0	0	381	0	0	0	0
52 MECH	9	300	119	699	2	0	119	0	0	701	0	0	26	52
WOC	8	7000	33	368	0	0	33	0	0	368	0	0	0	0
ATOC	7	5000	372	884	0	0	372	0	0	884	0	0	0	0
4ATAF	6	6000	908	786	0	0	908	0	0	786	0	0	0	0
23 ARM DIV	4	300	52	563	2	0	52	0	0	565	0	0	16	0
V CORPS	3	400	583	198	0	0	583	0	0	198	0	0	0	0
20 MECH	2	300	108	554	2	0	108	0	0	556	0	0	28	12
201 ACR	1	250	115	133	0	0	115	0	0	133	0	0	4	95

MSG-LOST 0 MSG-CONTENTS-CHANGED 0 MSG-REPEAT 0 MSG-PART-MISSING 0

CAS-WRONG-TARGET 0 CAS-ABORT 0

Another way to investigate the effects of electronic warfare (EW) is to assume that the EW actions cause messages to be lost. To show the effects of lost messages, a random loss of 80 percent of all messages entering Corps Tac was set. It is recognized that this is a high level and would require that the message centers of Corps Tac were effectively targeted. Table IV-6 shows a dramatic change in the communications traffic into and out of Corps Tac, and no corps-controlled helicopter or CAS sorties are arriving at the divisions.

In the operation of a command, control and communications system there are times during which only partial messages are received. To illustrate possible effects of partial messages, the rules are set so that Corps Tac receives partial messages for certain specific types of messages that affect the "decision processes" of the Corps Tac. These messages are the loss reports from division (or ACR), and these messages affect the corps perception of combat. The action on a specific type of message may correspond to a targeting of the type as might be accomplished by a signal warfare unit that was collecting information on a particular type of message. In the example chosen, the particular type is the loss report. The error or absence of reporting affects the perception of the Corps Tac and thus causes the "decision" as to allocation of corps resources to be different. In the test case used here, the message has a chance of going through with no difficulty, a higher chance that the receiving node will know the origin of the message and can thus request a clarification, and there is a possibility that the message will be completely unintelligible and the source is unknown so the message is essentially a lost message. Table IV-7, the summary output for the three days under these conditions, shows that the CAS and helicopter sorties arriving in support is appreciably different from the previous cases examined. (See, for example, Table IV-3.) The messages into and out of Corps Tac have changed somewhat, but a check of the specific messages is required to determine exactly what happened. The change in sorties is shown in Figure IV-14 that presents the Red losses at the 201st ACR on the first day (see Figure IV-9). There are other changes not shown here.

Table IV-6. SUMMARY OUTPUT WITH LOST MESSAGES TO CORPS TAC

SUMMARY OUTPUT AT TIME 144

UNIT	NUMBER	TYPE	COMMUNICATIONS LIMIT IN	OUT	HOLD	KILL	INPUT LIMIT IN	HOLD	KILL	OUTPUT LIMIT OUT	HOLD	KILL	SORTIES CAS	HELO
CAP	99	9999	0	0	0	0	0	0	0	0	0	0	0	0
V CORP SUP	23	495	0	6	0	0	0	0	0	6	0	0	0	0
USAFE	22	6500	103	2	0	0	103	0	0	2	0	0	0	0
USEUCOM	21	650	9	0	0	0	9	0	0	0	0	0	0	0
US SUPPLY	20	525	3	9	0	0	3	0	0	9	0	0	0	0
USAREUR	19	550	3	0	0	0	3	0	0	0	0	0	0	0
SHAPE	18	700	175	42	0	0	175	0	0	42	0	0	0	0
AFCENT/AAFC	17	600	770	422	0	0	770	0	0	422	0	0	0	0
VII CORPS	16	400	27	12	0	0	27	0	0	24	0	0	0	0
VII CORP TA	15	450	113	48	0	0	113	0	0	48	0	0	0	0
CENTAG	14	500	243	112	0	0	243	0	0	155	0	0	0	0
V CORP REAR	13	490	184	66	0	0	184	0	0	122	0	0	0	0
V CORPS TAC	12	450	439	26	0	0	439	0	0	157	0	0	0	0
52 MECH	9	300	67	254	0	0	67	0	0	705	0	0	0	0
NOC	8	7000	13	342	0	0	13	0	0	342	0	0	0	0
ATOC	7	5000	354	871	0	0	354	0	0	871	0	0	0	0
4ATAF	6	6000	887	760	0	0	887	0	0	760	0	0	0	0
23 ARM DIV	4	300	31	549	0	0	31	0	0	564	0	0	0	0
V CORPS	3	400	558	147	0	0	558	0	0	197	0	0	0	0
20 MECH	2	300	68	244	0	0	68	0	0	545	0	0	0	0
201 ACR	1	250	77	44	0	0	77	0	0	133	0	0	0	0

MSG-LOST 1148 MSG-CONTENTS-CHANGED 0 MSG-REPEAT 0 MSG-PART-MISSING 0
CAS-WRONG-TARGET 0 CAS-ABORT 0

Table IV-7. SUMMARY OUTPUT FOR PARTIAL MESSAGE CASE

SUMMARY OUTPUT AT TIME 144

UNIT	NUMBER	TYPE	COMMUNICATIONS LIMIT IN	OUT	HOLD	KILL	INPUT LIMIT IN	HOLD	KILL	OUTPUT LIMIT OUT	HOLD	KILL	SORTIES CAS	HELO
CAP	99	9999	0	0	0	0	0	0	0	0	0	0	0	0
V CORP SUP	23	495	0	6	0	0	0	0	0	6	0	0	0	0
USAFE	22	6500	103	2	0	0	103	0	0	2	0	0	0	0
USEUCOM	21	650	9	0	0	0	9	0	0	0	0	0	0	0
US SUPPLY	20	525	3	9	0	0	3	0	0	9	0	0	0	0
USAREUR	19	550	3	0	0	0	3	0	0	0	0	0	0	0
SHAPE	18	700	202	42	0	0	202	0	0	42	0	0	0	0
AFCENT/AAFC	17	600	844	473	0	0	844	0	0	473	0	0	0	0
VII CORPS	16	400	54	24	0	0	54	0	0	24	0	0	0	0
VII CORP TA	15	450	114	48	0	0	114	0	0	48	0	0	0	0
CENTAG	14	500	348	206	0	0	348	0	0	206	0	0	0	0
V CORP REAR	13	490	179	108	0	0	179	0	0	108	0	0	0	0
V CORPS TAC	12	450	1485	336	0	0	1485	0	0	335	0	0	0	0
52 MECH	9	300	124	711	0	0	124	0	0	711	0	0	14	32
WOC	8	7000	30	372	0	0	30	0	0	372	0	0	0	0
ATOC	7	5000	385	900	0	0	385	0	0	900	0	0	0	0
4ATAF	6	6000	925	790	0	0	925	0	0	790	0	0	0	0
23 ARM DIV	4	300	52	570	0	0	52	0	0	570	0	0	16	0
V CORPS	3	400	572	193	0	0	572	0	0	193	0	0	0	0
20 MECH	2	300	105	543	0	0	105	0	0	543	0	0	16	4
201 ACR	1	250	102	144	0	0	102	0	0	144	0	0	0	32

MSG-LOST 0 MSG-CONTENTS-CHANGED 0 MSG-REPEAT 27 MSG-PART-MISSING 34

CAS-WRONG-TARGET 0 CAS-ABORT 0

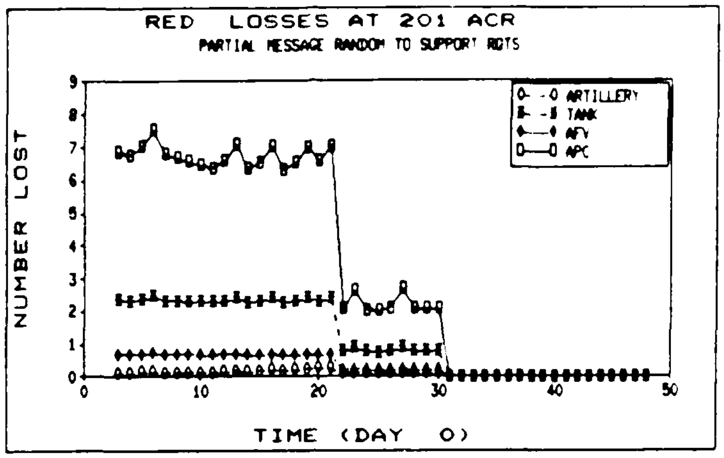


Figure IV-14. RED LOSSES AT THE 201ST ACR WITH PARTIAL MESSAGES, DAY 0

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